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Results of the 1991 Dogwood Anthracnose Impact Assessment and Pilot Test in the Southeastern United States

Protection Report (2)
R8-PR 23

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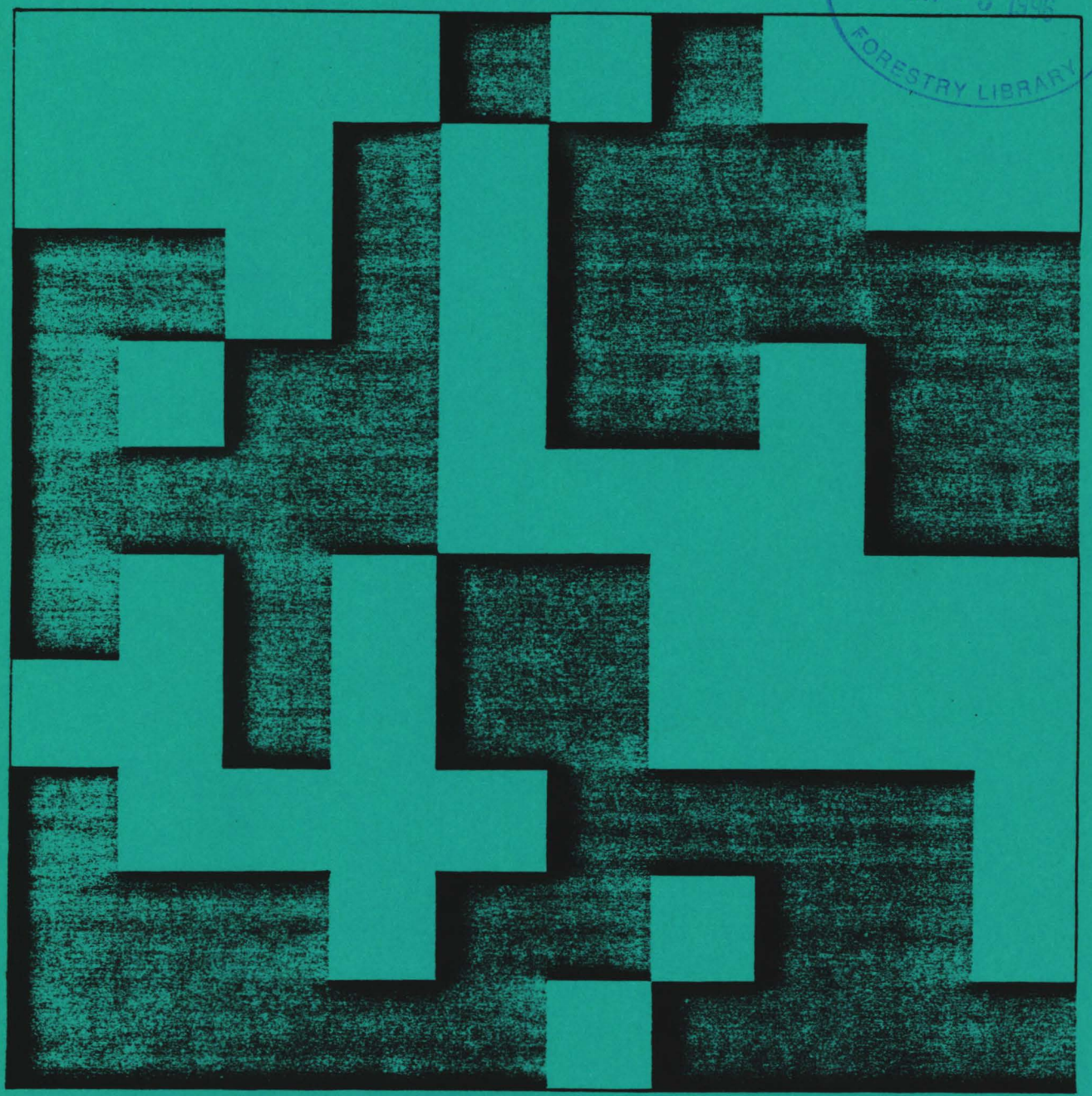

Results of the 1991 Dogwood Anthracnose Impact Assessment and Pilot Test in the Southeastern United States

Protection Report R8-PR 23

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Contents

	Page
Contributors	v
Background	1
Summary	5
Agencies That Participated in the Impact Assessment and Pilot Testing	6
Report Summaries	7
Individual Studies	
Distribution of Dogwood Anthracnose in the Southeastern United States - December 1991	13
Dogwood Anthracnose Impact Assessment in the Southeast - 1991	21
Progress on Development of a Geographic Information System Hazard Rating for Dogwood Anthracnose	30
Distribution of Dogwood Anthracnose in the Great Smoky Mountain National Park and Effects of Proximity of Water to Plots and Plot Aspect on Disease Severity	31
Effect of Tree Placement and Plot Aspect on Dogwood Anthracnose Disease Severity and Dogwood Reproduction	36
Effectiveness of Cultural Techniques, with Emphasis on Fertilization, to Control Dogwood Anthracnose	43
Effect of Nitrogen and Phosphorus Fertilization on Infection and Disease Development	47
A Cooperative Pilot Test to Determine the Effects of Media pH, Fertilization Rates, and Moisture Stress on the Infection by the Dogwood Anthracnose Fungus (*Discula* sp.) on Flowering Dogwood, *Cornus florida* L	48
Control of Dogwood Anthracnose With Fungicide Treatments at Two Locations in Tennessee	51
Evaluation of Fungicide Foliar Sprays and Trunk Injections on Control of Dogwood Anthracnose	54
Development of an Inoculation System for Infection of Flowering Dogwoods with *Discula* sp. at the Resistance Screening Center, 1991	56

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Pesticide Precautionary Statement

This publication reports pilot testing involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife–if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Background

Dogwood anthracnose is a disease of flowering and Pacific dogwood, (*Cornus florida* L. and *C. nuttallii* Audubon). Infection of Pacific dogwood has been reported from Washington, Oregon, Idaho, and British Columbia. In the South, infections have been reported on flowering dogwood in Virginia, North and South Carolina, Tennessee, Georgia, Kentucky, and Alabama.

Infection of dogwoods is favored by cool, wet spring and fall weather but can occur throughout the growing season. Drought and winter injury weaken trees and may increase disease severity. Consecutive years of heavy infection have resulted in extensive mortality of both woodland and ornamental dogwoods. The origin of this disease is unknown, but it is suspected to have been introduced.

Dogwood anthracnose was first reported in 1978. It was causing a widespread, rapid deterioration of flowering dogwood in New York and Connecticut. In 1983, Daughtrey and Hibben (2) reported a lower branch dieback disease with the same symptoms on flowering dogwood in New York, Connecticut, New Jersey, and Pennsylvania. They made observations on trees in Planting Fields Arboretum, Oyster Bay, Long Island, and a woodland site at the Brooklyn Botanic Garden Research Center in Ossining, NY. They reported the cause of the disease to be a species of *Discula* sp. Daughtrey and Hibben (2) reported that the reason for a sudden onset of anthracnose over part of the northeastern range and its coincidental outbreak on western flowering dogwood was unknown. They speculated that climatic changes may have been a factor and that the disease may have been introduced. Hudler proposed that droughts or sudden changes in the environment may have predisposed the trees to infection (3). In 1984, a survey of dogwood anthracnose was made in Catoctin Mountain National Park. Mielke and Langdon in 1986 found that only 3 percent of the dogwoods were disease free, and that about one-third were dead (5). Schneeberger and Jackson repeated the survey in 1988 and found that 89 percent of the dogwoods were dead, that there was almost no regeneration, and that all remaining trees were diseased (7).

Byther and Davidson described a similar disease on western flowering dogwoods in western Washington and named it "dogwood anthracnose." The disease was reported in Oregon, Idaho, and British Columbia in 1983 (1). The causal organism was reported to be *Discula* sp. Daughtrey and Hibben compared the symptoms, signs, and organisms on the western flowering dogwood and the eastern flowering dogwood. They concluded that the same disease occurs in both areas. It was at this time that the disease on eastern flowering dogwood was named "dogwood anthracnose" (2). In 1985, Mielke and Daughtrey wrote a pest alert designed to help assess the distribution and spread (4). By 1987 the disease had been reported in over 60 counties in 9 Northeastern States (Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Virginia, and West Virginia). In the late 1970's and early 1980's there was considerable speculation as to whether dogwood anthracnose could successfully spread to the Southeastern United States. In October of 1987, unusual numbers of dogwoods were reported dying on the Cohutta Ranger District on the Chattachoochee National Forest in northern Georgia. All of the symptoms matched those of dogwood anthracnose. Foresters estimated that the affected area covered about 30,000 acres of the Cohutta Wilderness. *Discula* sp., the causal organism of dogwood anthracnose, was isolated from samples from the affected area.

The National Forest Supervisor and State Forester of Georgia were notified of the occurrence. Soon thereafter, Bob Zahner, a professor from Clemson University, reported an unusual problem with the dogwoods in Cashiers, NC. This area was checked and *Discula* sp. was found. In this case, the affected area was much larger than the 30,000 acres found in Georgia. The State Forester of North Carolina was notified, and a meeting of State and Federal personnel from the affected and adjacent States was held in Dillard, GA, in February 1988. This group became a dogwood anthracnose working group and agreed that the top priority was to assess the disease distribution. The Southern Region of the Forest Service distributed a southern version of the dogwood anthracnose pest alert.

By the second meeting of the working group in May of 1988, the disease had been found in Georgia, North Carolina, South Carolina, Tennessee, and Virginia. It was reported that the disease affected trees of all sizes

and was more common in the mountains and cool, wet valleys. Six nurseries in North Carolina and one in South Carolina were reported to have diseased trees. Fungicide trials were started in Georgia and Tennessee, and a joint pilot-test proposal was prepared for submission to the Washington Office. Coleman Doggett, North Carolina Pest Control Forester proposed that permanent plots be established on a 15-mile grid to assess the current and future impacts. These plots were installed by State and Federal personnel in each of the respective States. In June of 1988, the fungus had been found in so many locations that the USDA Forest Service and the University of Georgia began to provide sample identification services. In September the working group developed a news release, but it was decided not to send the release until more information was collected. After this point, the information became known to the press and public. As a result, the news release was never issued. The National Park Service did distribute a news release from the Great Smoky Mountains National Park. Dogwood anthracnose and its impact received major media coverage.

At this point, a lot of work was being done, and the working group concept was good, but the process was reactive and information was not being managed to assist in the process. The public was getting scarce information from the press, and politicians were responding to the problem without knowing the whole story. A third meeting of the dogwood anthracnose working group was held in October 1988. By this time, a funding proposal had been submitted to the Washington Office for consideration. The disease had been identified in 49 counties in the South, and 60 permanent plots had been established to assess impact. Birds were discussed as possible vectors, and fungicide studies in Georgia had not produced positive results. Fungicides had been applied in the late summer. One important concern was the inability to inoculate trees under controlled conditions. A high priority was placed on this task. In November of 1988 the Great Smoky Mountain National Park, in cooperation with the University of Tennessee, completed a survey of the Park and found the disease was widespread.

In January of 1989, the Regional Forester for the Southern Region of the USDA Forest Service called a meeting of the Federal and State cooperators to discuss dogwood anthracnose. At this meeting, a list of priorities was developed for survey, impact assessment, and research, and a dogwood anthracnose steering committee was developed to help with the biological and political aspects of the problem.

In March 1989, eight national forests were surveyed to assess the distribution. At the same time, a greenhouse inoculation test was completed with positive results. Anderson, Knighten, and Dowsett found when seedling leaves were pretreated with an acid mist, fungus spores routinely produced infections on them. Results led to a controlled acid rain study where a positive correlation was established between simulated acid rain and infection in the greenhouse. Funding was approved for a pilot test of control techniques, and several studies were started by the USDA Forest Service, the University of Tennessee, the University of Georgia, and the National Park Service.

In the spring of 1989, the media coverage picked up considerably. The story ran in dozens of newspapers and on radio and TV. CBS National News did a Saturday segment on the disease. Realizing the need to provide the best information possible to the public, the USDA Forest Service, the University of Georgia, and the State Forester of Georgia developed and published a booklet on how to manage dogwood anthracnose. To keep public officials informed, a briefing package was developed by the Forest Service. The package included a briefing paper and a list of people to be contacted. It was about this time that the correlation between simulated acid rain and dogwood anthracnose was released. Because of the interest in acid rain, major political problems arose as the information was released to the press. In 1990, the acid rain study was repeated and showed the same result. At this time, proposals for research and impact assessment were being submitted to the Washington Office. The Southeastern Forest Experiment Station assigned one person to work part time on the disease in 1989. By this time, the disease had been found in 57 counties in 7 Southern States.

By 1990 considerable information was accumulating. It was noted that the fungus seemed to remain active and grow down the dogwood shoots in the winter. The disease was more common at high elevations and in cool, wet coves was able to spread over large areas very quickly (81 counties now had diseased trees), and the

fungus preferred cool temperatures. Pilot-test data showed that the fungicides Benlate and Daconil were providing effective control and that other fungicides showed promise. Fertilization and mulching seemed to improve tree vigor, while not increasing the disease in the field. Other greenhouse and field tests were showing that phosphorus tended to increase and lime tended to reduce disease symptoms.

Nevertheless, we still knew very little about this complex problem. Early literature reported that there was no resistance in the native flowering dogwood populations, but people were noting some trees in the field that seemed to show resistance. Resistance became a high priority for research in 1990.

In September of 1989, the working group met again to discuss progress. Eighty-four counties were reported with diseased trees, and the impact plots showed the disease had increased from 1/2 million acres in 1988 to 2.2 million acres in 1989. The National Park Service announced that it would investigate mycological aspects of the problem. Forest Service research officials reported that they would be working on epidemiology.

In December 1989, Kerry Britton of the Southeastern Forest Experiment Station held a research planning meeting in Athens, GA. The Station had received funding for anthracnose research, and the purpose of the meeting was to develop a plan for the next 5 years.

Forest Pest Management recently evaluated a forest stand that had a major component of dogwood near Asheville, NC. After about 3 years of infection, 42 percent of the dogwoods have died, the remainder are infected, and there is no regeneration. The disease is spreading rapidly, heavily impacting large areas.

In the fall of 1990, the Southern Appalachian Man and Biosphere Cooperative, consisting of the U.S. Environmental Protection Agency, Forest Service, Park Service, Southeastern Forest Experiment Station, Fish and Wildlife Service, Department of Energy, Economic Development Administration, and the Tennessee Valley Authority, organized two dogwood anthracnose conferences. One was held in Knoxville, TN, and the other in Asheville, NC. These conferences consisted of representatives from Federal, State, and private concerns, and featured speakers from a number of these agencies. The program reflected a diversity of views held by various groups throughout the South. These meetings increased the awareness of and understanding of dogwood anthracnose, and helped define specific goals, such as effective information dissemination.

The distribution has been difficult to determine. For any major disease problem, the first question is "Where is the disease found?" Incidence maps are the best reply. Since there are so many mimicking symptoms, it was decided that for a county to be designated "affected," disease presence had to be confirmed in the laboratory. In 1990, the plot data were added to a Geographic Information System to generate maps displaying both severity and incidence. In 1991, the disease had been confirmed in 163 counties in 7 Southeastern States.

In January 1991, another working group meeting was held. Members reported progress in all areas. Five hundred thousand copies of an updated version of "Growing and Maintaining Healthy Dogwoods" including revised control methods were published. Also in 1991, the fungus causing dogwood anthracnose was described as "*Discula destructiva* sp. Nov." (6) and dogwood resistance screening was developed.

For impact assessment, some 210 permanent 10-tree dogwood plots have been established in North Carolina, South Carolina, Tennessee, Alabama, Virginia, Kentucky, and Georgia. These plots are selected in a random stratified sample on a 15-mile grid. Data for 1988 and 1989 show that the disease increased dramatically (from about 1/2 million acres in 1988 to 9.6 million acres in 1991), and the severity in the permanent plots has increased. Obviously, the rapid increase in the area affected and reflects discovery of stands infected for some time, in addition to actual yearly increase. However, from observation of infection in relatively large geographic areas, it is clear that there was a major increase in the disease incidence and impact in 1989, 1990, and 1991.

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Summary

By December of 1991, dogwood anthracnose had been found in 163 counties in 7 Southern States. The increase over 1990 in number of affected counties was 23 percent. About 9.6 million acres are estimated to be affected, and mortality is increasing. Preliminary work on hazard rating systems seems to show a correlation between disease severity and elevation and aspect. The higher the elevation and the more northern and western the aspect, the more severe the damage to dogwoods. In addition, work by the Great Smoky Mountain National Park has shown a relationship between disease occurrence and the proximity to water. University of Tennessee scientists have documented a major increase in disease occurrence in the Great Smoky Mountain National Park in 1991. They have also been able to demonstrate that increased sun exposure can reduce disease severity. The following recommended cultural control techniques appear to be effective in reducing disease severity:

1. Select healthy trees to plant.
2. Purchase trees from a reputable nursery; do not transplant trees from the wild.
3. Select planting sites where foliage will dry rapidly in the morning and afternoons.
4. Use proper planting techniques.
5. Prune and destroy dead wood and leaves yearly; prune trunk sprouts in the fall.
6. Water weekly in the morning during droughts. Caution: Do not wet foliage.
7. Maintain 3- to 4-inch-deep mulch around trees; do not use dogwood chips as a mulch.
8. Fertilize according to soil analysis.
9. Use proper insecticide and fungicide where appropriate.
10. Avoid mechanical and chemical injury to trees.

As a result of the pilot testing, the pruning, watering, mulching, and fungicide recommendation have been modified. General pruning seems to be of little value, but removal of epicormic shoots helps to prevent stem infection. Watering during drought is effective, but the watering must be done in the morning and must not touch the foliage. Mulching helps by reducing moisture stress and reducing trunk wounding, but too much mulch (over 4 inches) can be detrimental. All fertilizer treatments resulted in reduced infection when compared with the check.

A number of fungicides were sprayed on foliage, and injected into stems. Several fungicides worked as foliage sprays and some gave some control with injections. Two registered fungicides, Benlate and Daconil, gave excellent control as foliage sprays. Other fungicides, such as Lynx and Banner, gave better control. Lynx is not registered for this purpose but, Banner is in the process of being labeled. This is especially significant since the label for Benlate has been withdrawn.

An inoculation system was developed by the Resistance Screening Center, FPM, in 1991 to infect a large number of dogwood seedlings at one time. Also, Region 8 collected dogwood seeds from 129 geographic locations in 1991 and the Resistance Screening Center will begin screening them for resistance in 1992.

The final year of the dogwood anthracnose pilot testing will be 1992. Impact assessment will continue in 1993. The final year of pilot testing will focus on hazard rating, fungicides, fertilization interaction, and cultural control techniques. The impact assessment will continue to track the distribution and losses.

Agencies That Participated in the Impact Assessment and Pilot Testing

USDA Forest Service - Forest Pest Management

- Impact Assessment of the Southeast
- Distribution of Dogwood Anthracnose
- Cultural and Chemical Control Techniques
- Fertilization
- Resistance Screening

University of Georgia

- Chemical and Cultural Control Techniques
- Fertilization

Great Smoky Mountain National Park

- Hazard Rating
- Chemical and Cultural Control

State Foresters' Offices - Alabama, North Carolina, South Carolina, Virginia, Georgia, and Tennessee.

- Distribution of Dogwood Anthracnose
- Impact of Dogwood Anthracnose

North Carolina Department of Agriculture Extension Service

- Fertilization

Report Summaries

The individual report section contains the detailed reports for each of the assessments and pilot tests. A brief summary of each report follows:

Distribution of Dogwood Anthracnose in the Southeastern United States - December 1991 (Forest Pest Management)

Since dogwood anthracnose was found in the Southeastern United States, people from State, Federal, and private concerns have helped track its distribution. To be added to the distribution map, the diseased trees must be present in the county and have *Discula destructiva* confirmed in the laboratory. By December 1991, 163 counties in 7 Southern States were classified as having infected trees.

Dogwood Anthracnose Impact Assessment in the Southeast - 1991 (Forest Pest Management)

Two hundred and ten permanent dogwood plots have been established in dogwood-anthracnose-affected counties in Virginia, North Carolina, South Carolina, Georgia, Kentucky, Tennessee, and Alabama. These plots were selected as a random stratified sample on a 15-mile grid. The acreage affected in the Southeast was estimated at about 1/2 million acres in 1988, 2.2 million in 1989, 5.7 million in 1990, and 9.6 million acres in 1991. Mortality increased from 0 to 8 percent from 1988 to 1991, and severely damaged trees increased from 4 to 14 percent.

Progress on Development of a Geographic Information System Hazard Rating for Dogwood Anthracnose (Great Smoky Mountain National Park)

To validate the model produced in 1990, over 160 km (100 miles) of trails were rated subjectively as to the general health of dogwood stands. Criteria used to rate stands were the same as that used previously. Digitization has been completed for all data, but assessing accuracy of the dogwood anthracnose hazard rating and the new moisture model developed for the park will not be complete until mid-February 1992.

Distribution of Dogwood Anthracnose in the Great Smoky Mountain National Park and Effects of Proximity of Water to Plots and Plot Aspect on Disease Severity (University of Tennessee and Great Smoky Mountain National Park)

Dogwood anthracnose has become more severe in the Great Smoky Mountain National Park over the last 4 years and is now common on both the North Carolina and the Tennessee sides of the park. As the disease becomes more severe, tree mortality increases and dogwood reproduction decreases. If the rate of spread of the disease and the rate of mortality continue as in the last 4 years, dogwoods may completely disappear from the park (areas close to water and/or with northern aspects). Dogwoods that are growing on dry southern slopes and/or more than 50 m from water may survive for many years.

Effect of Tree Placement and Plot Aspect on Dogwood Anthracnose Disease Severity and Dogwood Reproduction (University of Tennessee)

Effects of plot aspect (direction of slope), plot elevation, and tree placement (sun or shade) on dogwood anthracnose severity and dogwood reproduction were studied at three locations: along the Blue Ridge Parkway in Virginia, in the Cherokee National Forest in Polk County in Tennessee, and on Lookout Mountain in Tennessee. Trees located in sunny areas, with south to west aspects, and/or at lower elevations (> 460 m) had less diseased foliage and higher reproduction rates than trees in full shade, with north to east aspects and/or at higher elevations (< 460 m).

Effectiveness of Cultural Techniques, With Emphasis on Fertilization, to Control Dogwood Anthracnose (Forest Pest Management)

Ornamental dogwood trees at the Bent Creek Experimental Forest in Asheville, NC, were treated with different cultural techniques. All treated trees were pruned, mulched, and sprayed for dogwood borers. In addition, some trees received nitrogen, phosphorus, lime, or a balanced fertilizer or were watered during dry periods in 1990. Check trees received none of the treatments. These trees received only pruning, mulching, and dogwood borer control in 1991. Watering was not needed in 1991. All trees were scored for disease symptoms on a score from 100 to 0, most severe to healthy, respectively. All fertilizer treatments were negatively correlated with disease development. Nitrogen and phosphorus fertilization lowered disease ratings. It appears that any fertilization, especially nitrogen and phosphorus, reduced disease severity.

Effects of Nitrogen and Phosphorus Fertilization on Infection and Disease Development (University of Georgia)

A field study of the effects of high nitrogen and phosphorus on potted dogwoods was established in 1990 and continued in 1991 at the Georgia Mountain Experiment Station in Blairsville, GA. All trees were artificially inoculated in mid-April and mid-May. Extensive development of spot anthracnose and septoria leaf spot was detected, and very little dogwood anthracnose was observed. The study will continue in 1992 with addition of shade cloth to promote anthracnose development.

A Cooperative Pilot Test to Determine the Effects of Media pH, Fertilization Rates and Moisture Stress on the Infection by the Dogwood Anthracnose Fungus (*Discula* sp.) on Flowering Dogwood, *Cornus florida* L. (North Carolina Agricultural Extension Service)

Some 330 budded dogwood plants were potted in 3 pH levels (5.5, 6.0, and 6.5) and fertilized weekly with 3 levels of nitrogen media at (50, 100, and 200 p/m N). A high phosphorus and a moisture stress treatment also were included. Plants were artificially inoculated twice with natural inoculum from the field. Only one of the six replications had significant infection. In that replication, the higher nitrogen treatment had a significantly higher infection level. All fertilized plants looked healthier than the other dogwoods in the area.

Control of Dogwood Anthracnose With Fungicide Treatments at Two Locations in Tennessee (University of Tennessee)

Twelve fungicide treatments were evaluated for dogwood anthracnose control at the Great Smoky Mountain National Park in Tennessee and at Ozone, TN. Dogwood trees sprayed with Banner or Lynx at intervals of up to 4 weeks had significantly less diseased foliage than did trees that served as controls. Trees sprayed with 0.31 or 0.63 mL/L of Banner had phytotoxicity symptoms including necrotic flecking, leaf distortion, and a silvery appearance of the leaves.

Evaluation of Fungicide Foliar Sprays and Trunk Injections on Control of Dogwood Anthracnose (University of Georgia)

Seven foliar spray and seven trunk injection treatments were imposed in the Duke's Creek Falls area of the Georgia mountains where dogwood anthracnose has been epidemic. Twenty-five leaf pairs in the lower crown of each tree were rated for percentage of leaf showing necrosis on a scale of 0 = no symptoms, 1 = trace to 5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100%, and 6 = leaf abscised. Significant disease control occurred with both foliar sprays and trunk injections. Best results were obtained with the foliar sprays Lynx, Asc 66825, and Benlate. Trunk injections with Lynx, Aliette, and Arbotect provided significant control but were relatively ineffective compared with foliar sprays.

Development of an Inoculation System for Infection of Flowering Dogwoods With *Discula* sp. at the Resistance Screening Center, 1991 (Forest Pest Management)

Several systems for screening dogwood seedlings for resistance to *Discula* sp. were evaluated at the Resistance Screening Center. The best results were obtained in an open area covered by shade cloth and misted to maintain high humidity. The inoculation procedures consisted of suspending infected branches over the seedling plus artificial inoculation.

Individual Studies

Report #92-1-25

Distribution of Dogwood Anthracnose in the Southeastern United States - December 1991

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Abstract

Since dogwood anthracnose was found in the Southeastern United States, people from State, Federal, and private concerns have helped track its distribution. To be added to the distribution map, the diseased trees must be present in the county and have *Discula destructiva* (4) confirmed in the laboratory. By December 1991, 163 counties were classified in 7 Southern States as having infected trees.

Introduction

In the late 1970's a new disease (dogwood anthracnose) was found to be causing lower limb dieback and leaf lesions on flowering dogwoods (*Cornus florida* L.) in the Northeastern United States (2). In 1987 the disease, caused by the fungus *Discula destructiva* (3,4) was found to be affecting 30,000 acres of Cohutta Wilderness in northern Georgia (1).

Since the disease's discovery in the Southeastern United States, Federal, State, and private concerns have helped track the distribution and spread of the disease. Forest Pest Management, Region 8, has coordinated the data and prepared distribution maps.

Methods

In 1987 and 1988, the States of Georgia, North Carolina, South Carolina, and Tennessee; the National Park Service; and the USDA Forest Service conducted dogwood anthracnose road surveys of the mountains and foothills in their respective areas. Symptomatic dogwoods were sampled and samples were sent to the Horticultural Research Laboratory at Cornell University for confirmation of the disease. In each State where the disease was found, counties were listed if they had at least one naturally growing dogwood tree confirmed in the laboratory to be infected with the dogwood anthracnose fungus *Discula destructiva*.

In 1989, 1990, and 1991, the survey data came from anyone that discovered an infected tree and had it confirmed in the laboratory. The person or agency reporting a specific county has been maintained from the start of the mapping activities in 1987. Counties where all of the diseased trees have been removed are not added to the map. The maps are kept up to date with a Geographic Information System by the Regional Office in Atlanta, GA.

Results and Discussion

The list of counties in the Southeast has grown from 3 in 1987 to 163 in December 1991 (fig. 1 and table 1). In 1988 and 1989, the surveys and observations were detecting new areas and places where the disease had been around for some time. The surveys and observations in 1990 and 1991 began to pick up primarily the disease spread into new areas. However, there was a concentrated effort to survey the western counties of Virginia in 1991 for the first time (table 1). The date a county was confirmed and the source of information are listed in table 2.

The disease is primarily found in the mountains, foothills, and upper Piedmont. Damage severely increases with elevation and with moistness of areas at lower elevations.

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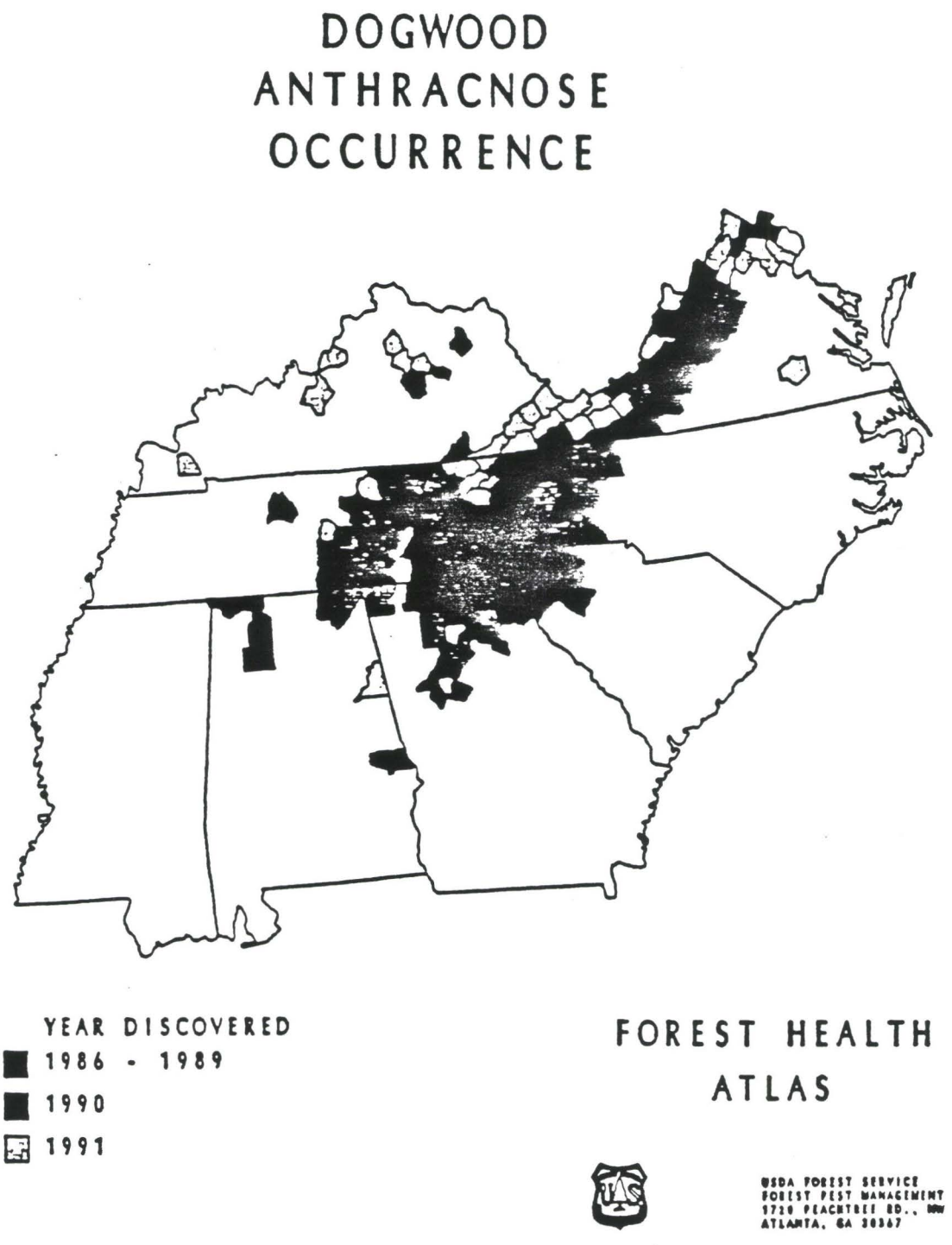
Figure 1–Distribution of dogwood anthracnose in the Southeastern United States as of December 1991.[1]



[1]Map was prepared by Bob Uhler and Steve Holzman with the Geographic Information System in the Regional Office.

Table 1--Number of new counties in Southern States, with laboratory-confirmed dogwood anthracnose infections on at least one flowering dogwood, by year

State	Year counties were added to the map					Total
	1987	1988	1989	1990	1991	
Alabama	--	--	3	2	1	6
Georgia	1	6	11	9	--	27
Kentucky	--	--	1	4	5	10
North Carolina	--	13	5	6	--	24
South Carolina	--	5	1	--	--	6
Tennessee	--	15	14	8	8	45
Virginia	2	3	13	5	22	45
Total	3	42	48	34	36	163

Table 2--The person or agency that first found dogwood anthracnose in a county and the year it was found

State	County	Year	Source of information
North Carolina	Allegheny	1989	S. Spencer, R. Baldwin
	Ashe	90	D. Rogers
	Avery	88	J. Knighten
	Buncombe	88	B. Anderson, J. Knighten
	Burke	89	S. Dowsett
	Caldwell	90	D. Rogers
	Cherokee	88	S. Dowsett
	Clay	88	S. Dowsett
	Cleveland	88	S. Oak
	Graham	88	B. Anderson, S. Dowsett
	Haywood	88	M. Windham (Smokies)
	Henderson	88	D. Ledford
	Jackson	88	B. Anderson, J. Knighten, D. Ledford
	Macon	88	B. Anderson, J. Knighten
	Madison	89	S. Dowsett
	McDowell	88	J. Knighten
	Mitchell	90	J. Knighten, S. Dowsett
	Polk	89	S. Spencer
	Rutherford	90	J. Knighten
	Swain	88	M. Windham (Smokies)
	Transylvaina	88	B. Anderson, J. Knighten, D. Ledford
	Watauga	89	NCSU Plant Path. Clinic
	Wilkes	90	D. Rogers
	Yancey	90	Plot Data
Virginia	Albemarle	90	J. Stipes
	Allegheny	91	Va. Dept. of Forestry
	Amherst	89	T. McCartney
	Augusta	89	J. Knighten
	Bath	89	T. McCartney
	Bedford	89	Blue Ridge Parkway
	Bland	91	Va. Dept. of Forestry
	Botetourt	89	Blue Ridge Parkway
	Buchanan	91	Va. Dept. of Forestry
	Carroll	89	Blue Ridge Parkway
	Clarke	87	Data from Plant Disease
	Craig	89	T. McCartney
	Dickenson	91	Va. Dept. of Forestry
	Dinwiddie	91	Va. Dept. of Forestry
	Fauquier	91	Va. Dept. of Forestry
	Floyd	88	D. Anderson
	Franklin	89	Blue Ridge Parkway
	Fredrick	91	Va. Dept. of Forestry
	Giles	89	T. McCartney

Table 2--The person or agency that first found dogwood anthracnose in a county and the year it was found--Continued

State	County	Year	Source of Information
Virginia	Grayson	1989	Blue Ridge Parkway
	Greene	90	K. Langdon
	Highland	91	Va. Dept. of Forestry
	Lancaster	91	J. Artman
	Lee	91	Va. Dept. of Forestry
	Loudoun	86	Data from Plant Disease
	Montgomery	90	J. Stipes
	Nelson	88	J. Artman
	Northumberland	91	Todd Groh, J. Artman
	Page	91	Va. Dept. of Forestry
	Patrick	89	Blue Ridge Parkway
	Prince William	91	J. Artman
	Pulaski	91	J. Rauschenberger
	Rappahannock	91	Va. Dept. of Forestry
	Roanoke	89	Blue Ridge Parkway
	Rockbridge	88	Drake
	Rockingham	90	D. Rogers
	Russell	91	Va. Dept. of Forestry
	Scott	91	Va. Dept. of Forestry
	Shenandoah	91	J. Rauschenberger
	Smyth	91	Va. Dept. of Forestry
	Tazewell	91	Va. Dept. of Forestry
	Warren	90	S. Dowsett
	Washington	89	T. McCartney
	Wise	91	Va. Dept. of Forestry
	Wythe	91	Va. Dept. of Forestry
South Carolina	Anderson	89	A. Boone
	Greenville	88	A. Bonne
	Laurens	88	Plot Data
	Oconee	88	A. Boone
	Pickens	88	A. Boone
	Spartanburg	88	Plot Data
Alabama	Cleburne	91	N. Hess
	Jackson	90	B. Anderson, J. Knighten
	Lauderdale	89	N. Hess
	Lawrence	89	N. Hess
	Lee	90	W. Kelly
	Winston	89	N. Hess
Tennessee	Anderson	89	M. Windham
	Bledsoe	88	B. Kauffman
	Blount	89	M. Windham (Smokies)
	Bradley	91	B. Kauffman
	Campbell	90	B. Kauffman
	Cannon	91	B. Kauffman
	Carter	88	B. Kauffman
	Claiborne	91	B. Kauffman

Table 2--The person or agency that first found dogwood anthracnose in a county and the year it was found--Continued

State	County	Year	Source of information
Tennessee	Cocke	1989	M. Windham
	Coffee	89	B. Kauffman
	Cumberland	88	B. Kauffman
	Davidson	88	B. Kauffman
	Fentress	90	B. Kauffman
	Franklin	89	B. Kauffman
	Greene	88	B. Kauffman
	Grundy	88	B. Kauffman
	Hamblen	91	B. Kauffman
	Hamilton	88	B. Kauffman
	Hancock	91	B. Kauffman
	Hawkins	90	B. Kauffman
	Jefferson	91	B. Kauffman
	Johnson	88	B. Kauffman
	Knox	89	M. Windham
	Loudon	89	B. Kauffman
	Marion	88	B. Kauffman
	McMinn	89	B. Kauffman
	Meigs	91	B. Kauffman
	Monroe	88	B. Kauffman
	Morgan	88	B. Kauffman
	Overton	91	B. Kauffman
	Pickett	90	B. Kauffman
	Polk	88	M. Windham, B. Kauffman
	Putnam	89	B. Kauffman
	Rhea	89	M. Windham
	Roane	88	B. Kauffman
	Scott	90	B. Kauffman
	Sequatchie	89	B. Kauffman
	Sevier	88	M. Windham, (Smokies)
	Sullivan	89	S. Dowsett
	Unicoi	89	Plot Data
	Union	90	B. Kauffman
	Van Buren	89	B. Kauffman
	Warren	90	B. Kauffman
	Washington	88	B. Kauffman
	White	90	B. Kauffman
Kentucky	Bell	90	J. Hartman
	Clark	91	J. Hartman
	Fayette	91	J. Hartman
	Hardin	91	J. Hartman
	Jefferson	91	J. Hartman
	Madison	90	J. Hartman
	Marshall	90	J. Hartman
	Powell	90	J. Hartman
	Rowan	89	S. Dowsett
	Scott	91	J. Hartman

Table 2--The person or agency that first found dogwood anthracnose in a county and the year it was found--Continued

State	County	Year	Source of information
Georgia	Banks	1990	K. Baily
	Catoosa	90	M. Windham
	Cherokee	90	K. Baily
	Clarke	90	K. Baily
	Dade	90	M. Windham
	Dawson	89	F. Hendrix
	De Kalb	89	K. Baily
	Fannin	88	S. Dowsett
	Fayette	90	K. Baily
	Franklin	89	F. Hendrix
	Fulton	89	K. Baily
	Gilmer	88	S. Dowsett
	Gwinnett	90	K. Baily
	Habersham	88	Plot Data
	Hall	89	F. Hendrix
	Hart	89	F. Hendrix
	Henry	89	K. Baily
	Jackson	89	Ed Brown
	Lumpkin	89	J. Knighten
	Murray	87	S. Dowsett
	Pickens	90	K. Baily
	Rabun	88	B. Anderson, J. Knighten, S. Dowsett
	Stephens	89	F. Hendrix
	Towns	89	J. Knighten
	Union	88	K. Britton
	Walker	90	M. Windham
	White	88	K. Britton

Report # 92-1-23

Dogwood Anthracnose Impact Assessment in the Southeast - 1991

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Abstract

Two hundred and ten permanent dogwood plots have been established in counties affected by dogwood anthracnose in Virginia, North Carolina, South Carolina, Georgia, Kentucky, Tennessee, and Alabama. These plots were selected as a random stratified sample on a 15-mile grid. The acreage affected in the Southeast was estimated at about 1/2 million acres in 1988, 2.2 million in 1989, 5.7 million in 1990, and 9.6 million acres in 1991. Mortality increased from 0 to 8 percent from 1988 to 1991, and the percentage of severely damaged trees increased from 4 to 14 percent.

Introduction

Dogwood anthracnose [caused by *Discula destructiva* (3)] was found on flowering dogwoods (*Cornus florida* L.) in the Northeastern United States in the late 1970's (2). All sizes and ages of dogwoods were susceptible. In 1987, the disease was found in the Cohutta Wilderness in northern Georgia. The disease causes lower limb dieback and leaf lesions on flowering dogwoods.

Because the disease was new to the Southeast, and the effects were unknown, it was decided to establish a series of permanent plots (recommended by Coleman Doggett, North Carolina Forest Service) to assess the current effects and monitor changes over time.

Since the plots occurred on all ownerships, the USDA Forest Service and the States with affected counties assisted in the establishment and monitoring of the plots. Funding was provided by the Forest Service, Forest Pest Management, Washington, DC.

Methods

Two hundred and ten plots were established by State and Federal cooperators, depending on the ownership. The plots were installed on a latitude and longitude grid with a 15-minute interval. These points were plotted using a geographic information system. They were then transferred to road maps to assist in field location. The following steps were used at the map coordinate:

1. Locate nearest road to coordinate. Plot should be located within a 1-mile radius of coordinate. If no dogwood is found within a 1-mile radius, data sheet is marked "no dogwood."

2. From edge of road, determine compass heading and walk toward plot at least 2 chains (132 feet).

3. Mark plot center.

4. Locate, tag, and mark (spray paint base of tree) the 10 dogwood trees (including dead) closest to plot center regardless of size and condition. Establish plot even if less than 10 trees.

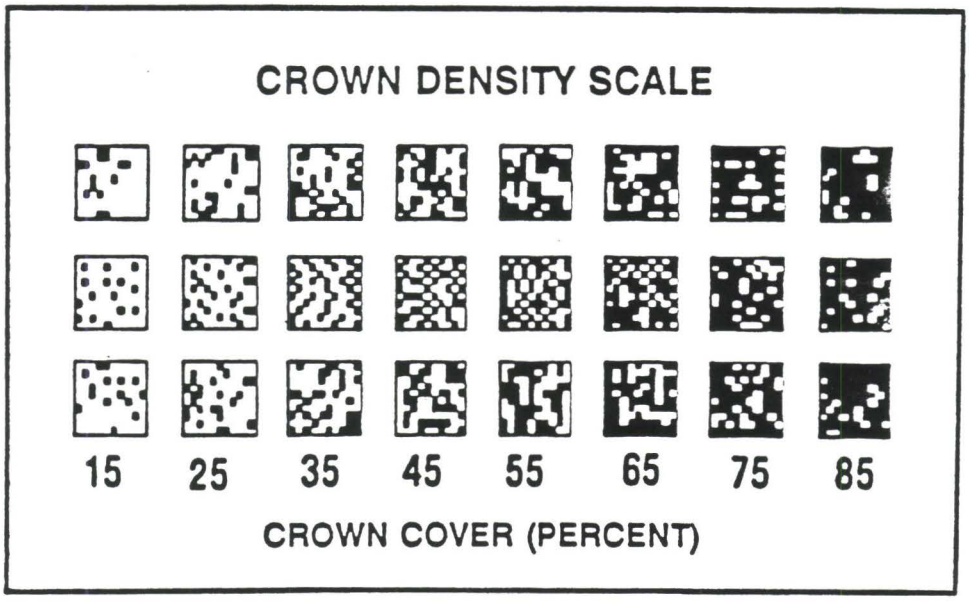
5. Make all necessary measurements and complete data sheet (fig. 1). Basal area consists of overstory trees only.

6. Collect sample of leaves or twigs from each tree suspected of having dogwood anthracnose. Mark collection bag so it can be identified by individual tree. Sample should be left dry and in a cool environment. Samples should be processed as soon as possible.

Data sheets were completed for each of the plots (fig. 1). The following Mielke-Langdon dieback classes (1) were used to rate the foliage of the trees:

Dieback classes
5 = Healthy
4 = 1-25% of foliage affected
3 = 26-50% of foliage affected
2 = 51-75% of foliage affected
1 = > 75% of foliage affected
0 = Dead

In an effort to more accurately appraise and record the condition of individual dogwoods on the impact plots, additional data were recorded on crown conditions. The full crown or the upper one-third of the tree, whichever is greatest, was examined. The density of living material on this portion was visually compared and matched to a category on the density scale card (below), and the resulting percentage was recorded.



All of the data were entered into a computer for analysis. The percentage of plots with confirmed *Discula destructiva* was determined for each State. The acreage of dogwood for each county in each State was obtained from Forest Inventory and Analysis. These county data were used to determine the total acres in affected counties, by State. The percentage of plots affected was then multiplied by the acres to estimate the acres affected, by State (e.g., dogwood acres in county times percent of positive plots).

Thirty of the 1988 plots which have been revisted in 1989, 1990, and 1991 were used to assess the change in damage classes using the Mielke-Langdon scale.

A GIS system was used to display the approximate location of each plot for this report.

Results and Discussion

Figure 2 shows the location of the permanent dogwood anthracnose plots in the Southeast. In 1988, about 14.8 percent of the permanent plots were confirmed as positive for *Discula destructiva*. By 1989 this had increased to 27.8 percent, to 50.3 percent in 1990, and to 64.3 percent in 1991. Using these percentages and estimates of total dogwood, the acreage affected was estimated at 1/2 million acres for 1988, 2.2 million acres for 1989, 5.7 million acres in 1990, and 9.6 million acres in 1991 (table 1).

Since each tree is classified on the Mielke-Langdon scale, 30 plots that were infected and have been remeasured three times were compared for changes over time. Table 2 shows that mortality has increased from 0 to 8 percent and severe damage (codes 2 and 1) from 4 to 14 percent.

The additional density (crown-cover) data is an estimate of the overall tree condition. These data show 55 percent of all live trees examined had a percentage between 26-50 percent with 34 percent of those trees positive for *D. destructiva* (table 3). Since the dogwood is an understory species, these results should be expected. The data indicate there may be a relationship between density and dogwood anthracnose. The percentage of positive trees progressively increases as the percentage of density decreases (table 3). Table 4 shows the positive plots, that 66 percent of the plot density averages were also in the 26-50 percent density group.

Overall, both the area affected by dogwood anthracnose and the severity of the disease have increased markedly in the Southeast. Some of the reported increase in area reflects newly discovered infection that have existed for some time, so only part represents truly new infections. The disease continues to be more severe at the higher elevations and in cool wet areas close to streams. These data are being used to construct hazard maps, which are not ready for use at this time.

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2. Daughtrey, M.L., C.R. Hibben, and G.W. Hudler. 1988. Cause and Control of Dogwood Anthracnose in Northeastern United States. Journal of Arboriculture 14(2):55.

3. Redlin, Scott, C. 1991. *Discula Destructiva* Sp. Nov., Cause of Dogwood Anthracnose. Mycologia, 83(5), 1991, pp. 633-642.

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Figure 1–Data sheet used to record data at each of the 210 permanent dogwood anthracnose plots - 1991.

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DOGWOOD ANTHRACNOSE IMPACT SURVEY

Date_____

State: _____ County: _____ Surveyor: _____

Location (Grid etc.): _____ (Draw map on back)

Aspect: _____ Elevation: _____ Basal Area: _____

Overstory Type: _____ Soil Type: _____

% Slope: _____ Landform (Ridge, Slope, Cove, Flatland): _____

Distance from plot center to farthest tree (ft): _____

Individual Tree Information

	1	2	3	4	5	6	7	8	9	10
Dieback Class										
DBH										
Height										
Stem Infection?										
Crown Cover (%)										
Sample?										
+/-										

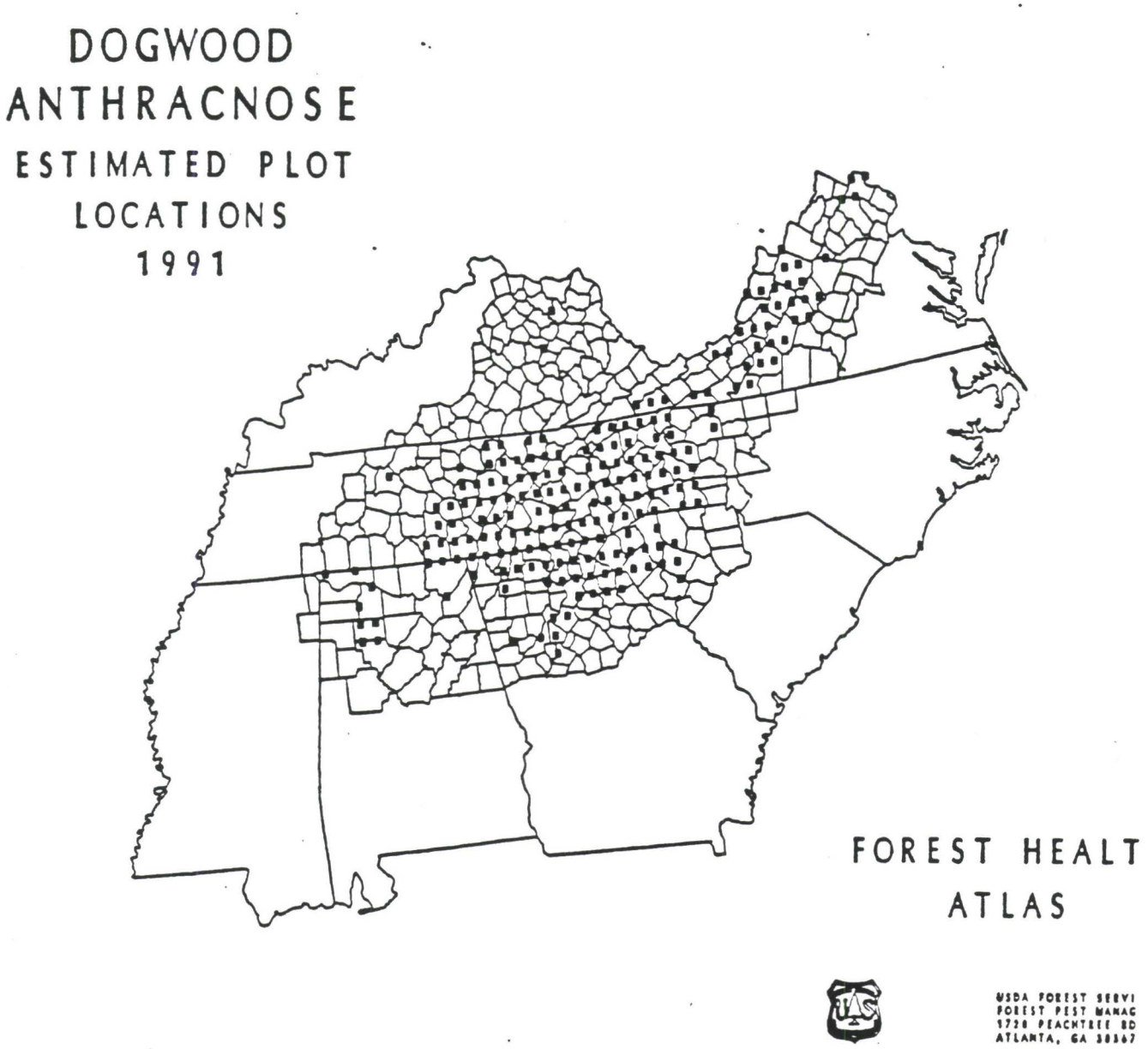
Misc. Information:

Instructions:

1. 10-tree plots on grid system.
2. Establish permanent plots - mark and number trees.
3. Record site and tree info.
4. Dieback Classes: 0 = Dead, 1 = > 75% foliage affected, 2 = 51-75%, 3 = 26-50%, 4 = 1-25%, 5 = Healthy.

Plot # # of Trees

Figure 2–Location of permanent dogwood anthracnose plots in the Southeast.[1]



[1]Map was prepared by Bob Uhler and Steve Holzman with the Geographic Information System in the Regional Office.

Table 1--Percentage and total acres affected by dogwood anthracnose in the Southeastern United States

State	1988			1989			1990			1991		
	Total acres	Acres affected	Acres affected	Total acres	Acres affected	Acres affected	Total acres	Acres affected	Acres affected	Total acres	Acres affected	Acres affected
		Number	Percent		Number	Percent		Number	Percent		Number	Percent
AL	0	0			0		0	0		0	0	
GA	693,132	153,875	(22.2)	1,847,076	369,415	(20.0)	2,313,671	832,922	(36.0)	2,313,671	1,059,661	(45.8)
KY	0	0		0	0		0	0		579,380	0	
NC	1,313,906	123,507	(9.4)	1,947,729	531,730	(27.3)	2,809,184	1,519,769	(54.1)	2,809,184	1,873,725	(66.7)
SC	899,385	158,292	(17.6)	1,005,699	295,675	(29.4)	1,005,699	737,177	(73.3)	1,005,699	804,559	(80.0)
TN	760,277	253,172	(33.3)	2,049,881	655,962	(32.0)	2,590,118	1,313,190	(50.7)	3,046,050	2,043,899	(67.1)
VA	90,765	13,433	(14.8)	1,246,177	346,437	(27.8)	2,619,682	1,205,054	(46.0)	4,769,194	3,610,279	(75.7)
Overall	3,757,465	556,105	(14.8)	8,096,562	2,250,844	(27.8)	11,338,354	5,703,192	(50.3)	14,523,178	9,584,923	(66.0)

NOTE: Alabama acreage data were not available for this report.

Table 2--Percentage of dogwood trees in each of six damage classes, with changes from 1988 to 1991

Damage class[1/]	1988	1989	1990	1991
		Percent		
5	38	8	24	24
4	51	66	48	38
3	7	17	14	15
2	3	4	7	7
1	1	4	4	7
0	0	1	3	8

1/ 5 = Healthy
4 = 1-25% of foliage affected
3 = 26-50% of foliage affected
2 = 51-75% of foliage affected
1 = > 75% of foliage affected
0 = Dead

Table 3--Number of all live trees and percentage of trees positive, by density groups

Density groups	Number of trees	Percentage of trees positive
25% or less	369	51
26-50%	973	34
51-75%	302	24
76% or more	113	6
Total	1,757	

Table 4--Number of positive plots by density groups

Density groups	Number of positive plots
25% or less	31
26-50%	84
51-75%	11
76% or more	0
Total	126

Progress on Development of a Geographic Information System Hazard Rating for Dogwood Anthracnose

K. Langdon, K. Johnson, M. Windham, and S. Powell

To validate model produced in 1990, over 160 km (100 miles) of trails were rated subjectively as to the general health of dogwood stands. Criteria used to rate stands were the same as that used previously (1).

Digitization has been completed for all data, but assessing accuracy of the dogwood anthracnose hazard rating and the new moisture model developed for the park (2) will not be complete until mid-February 1992.

Literature Cited

1. **Langdon, K., C. Parker, M. Windham, S. Powell, K. Johnson.** 1991. "A Preliminary Hazard Rating for Dogwood Anthracnose in the Southern Appalachians" in Results of the 1990 Dogwood Anthracnose Impact Assessment and Pilot Test in the Southeastern United States. USDA Forest Service, Forest Pest Management Protection Report R8-PR20. pp. 34-38.

2. **Parker, C.R., K.R. Langdon, J.R. Carter, S.C. Nodvin.** 1991. "Natural Resource Management and Research in Great Smoky Mountains National Park." Proceedings of Resource Technology 90. pp. 254-264.

Distribution of Dogwood Anthracnose in the Great Smoky Mountain National Park and Effects of Proximity of Water to Plots and Plot Aspect on Disease Severity

M.T. Windham, M.E. Montgomery, and K. Langdon

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Dogwood anthracnose, caused by *Discula destructiva* Nov. Redlin (2), has been monitored on permanent plots in the Great Smoky Mountain National Park (GSMNP) for 4 years (5). Thirty-four plots were visited in 1991 and data were collected on disease severity, tree death, plot aspect and evaluation, tree d.b.h. (diameter at breast height), dogwood reproduction, and proximity of plots to water.

Disease severity was estimated using the Mielke-Langdon dieback scale (1), which is described in figure 5. Tree death attributed to dogwood anthracnose included trees that had been girdled by elliptical cankers and/or had severe dogwood anthracnose symptoms in previous years. Plot aspect was determined and plots with aspect values of 316-45°, 46-135°, 136-225°, and 226-315° were grouped together, and means and values for standard error of the means were calculated. Plot elevation was measured with an altimeter. Tree-diameter data were collected at 1.2 m from the base of the tree trunk. Dogwood reproduction was estimated using the scale given in figure 4. Distances between plots and water (creeks, rivers, lakes, etc.) were measured, and data were grouped into water classes described in figure 5.

Results

Severe outbreaks of dogwood anthracnose ($\geq$ 25% diseased foliage) were scattered throughout GSMNP (fig. 1). Trees whose death was attributed to dogwood anthracnose were found in 41 percent of the plots, and these plots were also scattered throughout the park (fig. 2). Fewer plots with all healthy trees were found in 1991 than in 1988-1990 (fig. 3), and the number of plots with severe epidemics had greatly increased. Dogwood reproduction decreased within plots as disease severity increased (fig. 4). Dogwood anthracnose symptom severity was not correlated with d.b.h. or plot elevation.

Plots located close to water contained more trees with severe anthracnose symptoms than did plots on dry slopes (fig. 5). In addition, trees within plots with a northern aspect were more severely impacted by dogwood anthracnose than trees within plots with a eastern, southern, or western aspect (fig. 6).

Discussion

Dogwood anthracnose has become more severe in GSMNP over a 4-year period. The disease is common on both the Tennessee and North Carolina sides of the park (fig. 1). As the disease has become more severe, tree mortality has increased and dogwood reproduction has decreased. Similar increases in dogwood death and decreases in dogwood reproduction have been previously noted in Catoctin Mountain Park as dogwood anthracnose became more severe (1,3).

If both the rate of spread of dogwood anthracnose and the rate of dogwood mortality continue to increase as they have during the last 4 years, dogwoods may completely disappear from some areas of the park (areas close to streams and/or with northern aspects). However, dogwoods that are growing on dry southern slopes and/or more than 50 m from water may survive for many years. Plots located near water usually had more dense understories and overstories. High density may have led to increased humidity and less light intensity near dogwood canopies. Increased humidity would lengthen the period of time that leaves stay wet after

rainy periods and thus increase the period of time for fungal sporulation. Plots with northern aspects would receive less sunlight than plots on eastern, southern, or western aspects. Parham (unpublished) demonstrated that decreased light intensities at the surface of dogwood leaves led to decreased maximum temperatures of dogwood leaves, increased rates of growth of necrotic dogwood anthracnose lesions, and increased *Discula* spp. acervuli and cirri production. These differences may explain why dogwood anthracnose severity was greater in areas near streams and/or northern slopes.

Although small dogwoods were often observed to be more severely impacted by dogwood anthracnose than larger trees, dogwood d.b.h. was not significantly correlated with dogwood anthracnose incidence or severity. Since smaller (< 1.2 m tall) dogwoods in each plot were not utilized in this study, data collection was skewed to larger trees within each plot.

Plot elevation has been found to be correlated with dogwood anthracnose incidence and severity at other locations in Tennessee (4). In a previous study where dogwood anthracnose incidence and severity increased as plot elevation increased, severe outbreaks of the disease were found as low as 365 m (4). Generally, the elevation of GSMNP is higher than most other areas in Tennessee. Elevation of the lowest plot in GSMNP was 411 m. Therefore, plots may have been located too high to observe elevation effects on disease incidence and severity.

Literature Cited

1. **Mielke, M. and Langdon, K.** 1986. Dogwood anthracnose fungus threatens Catoctin Mt. Park. Park Sci. Winter:6-8.

2. **Redlin, S.C.** 1991. *Discula destructiva* sp. Nov., cause of dogwood anthracnose. Mycologia 83:633-642.

3. **Schneeberger, N. and Jackson, W.** 1989. Impact of dogwood anthracnose on flowering dogwood at Catoctin Mountain Park. Plant Dis. Quarterly. 10:30-43.

4. **Windham, M.** 1989. Epidemiology of dogwood anthracnose in Cherokee National Forest of southeastern Tennessee. Phytopathology 79:1149.

5. **Windham, M., Montgomery, M., and Langdon, K.** 1989. Disease incidence and severity of dogwood anthracnose in the Great Smoky Mountain National Park. Phytopathology. 79:377.

Figure 1–Distribution of dogwood anthracnose in the Great Smoky Mountain National Park in 1991. Open circles represent plots in which all trees were healthy; half-shaded circles represent plots where < 25 percent of foliage was symptomatic for dogwood anthracnose; shaded circles represent plots where ≥ 25 percent of foliage was symptomatic for dogwood anthracnose.

Figure 2–Distribution of plots in the Great Smoky Mountain National Park in which mortality of trees was attributed to dogwood anthracnose.

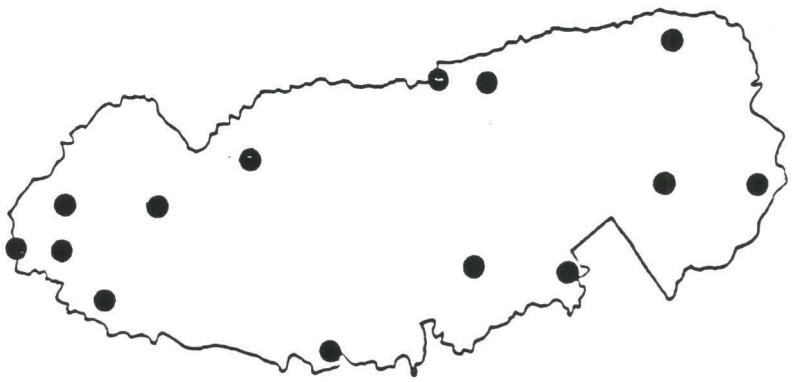


Figure 3-Percentage of plots in the Great Smoky Mountain National Park in which all trees are asymptomatic for dogwood anthracnose, atleast one tree within the plot had anthracnose lesions on its foliage, or diseased foliage within the plot ≥ 25 percent. Trees within each plot were tagged in 1988 and the same trees were surveyed in 1989, 1990, and 1991.

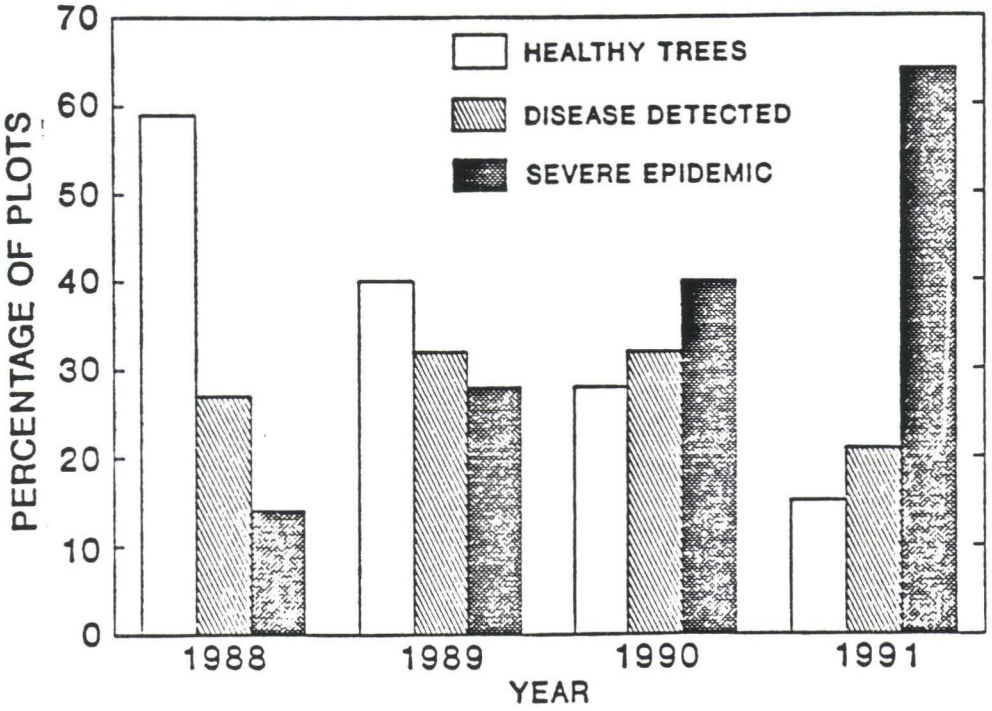


Figure 4-Effect of dogwood anthracnose disease severity on dogwood reproduction. Reproduction scale is: 0 = no reproduction, 1 = few flower buds or berries on trees; 2 = flower buds or berries common or few dogwood seedlings present; 3 = flower buds or developing berries common on trees and dogwood seedlings present.

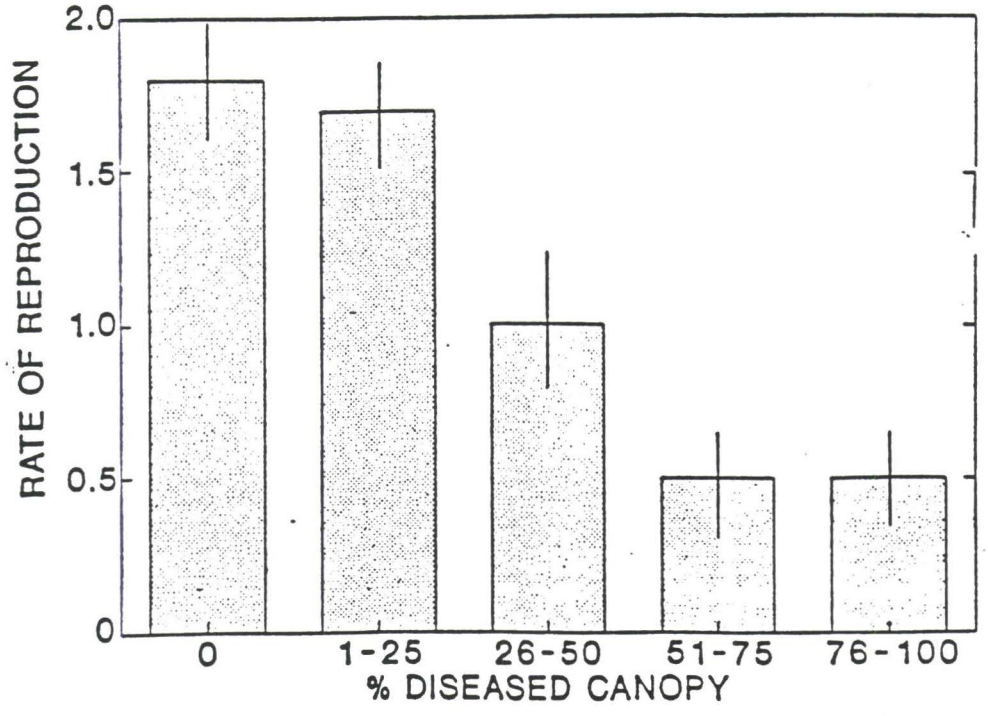


Figure 5–Relationship between the proximity of plots to water (streams, rivers, etc.) and dogwood anthracnose severity. Mielke-Langdon dieback scale (1) is 5 = healthy tree, 4 = 1-25% diseased foliage, 3 = 21-50% diseased foliage, 2 = 51-75% diseased foliage, 1 = 76-100% diseased foliage, 0 = no living foliage.

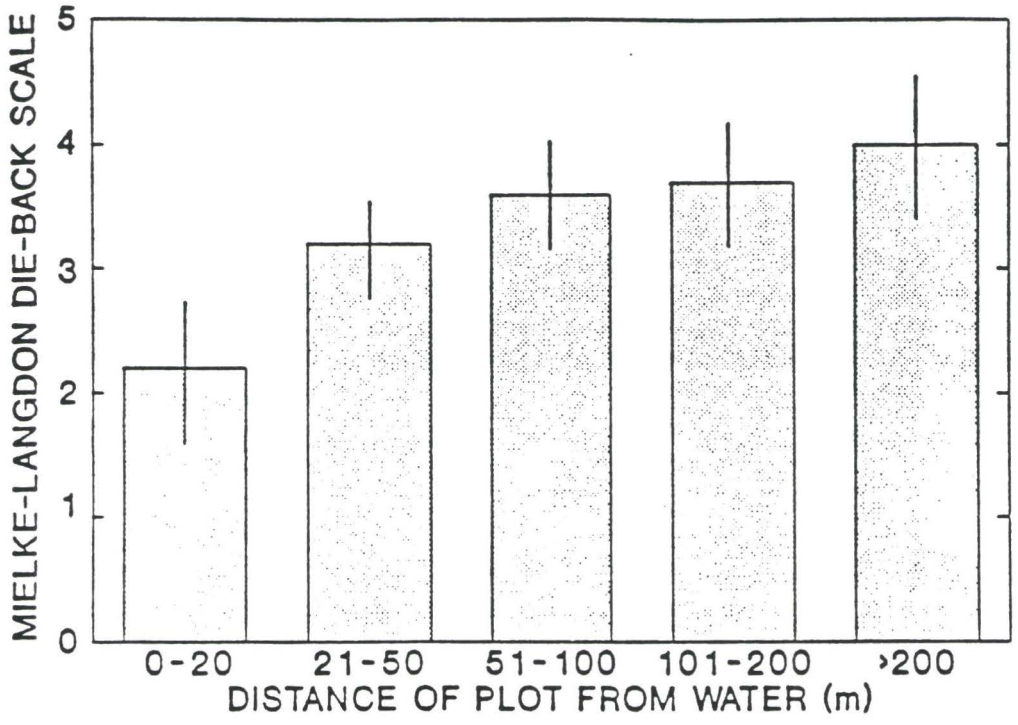
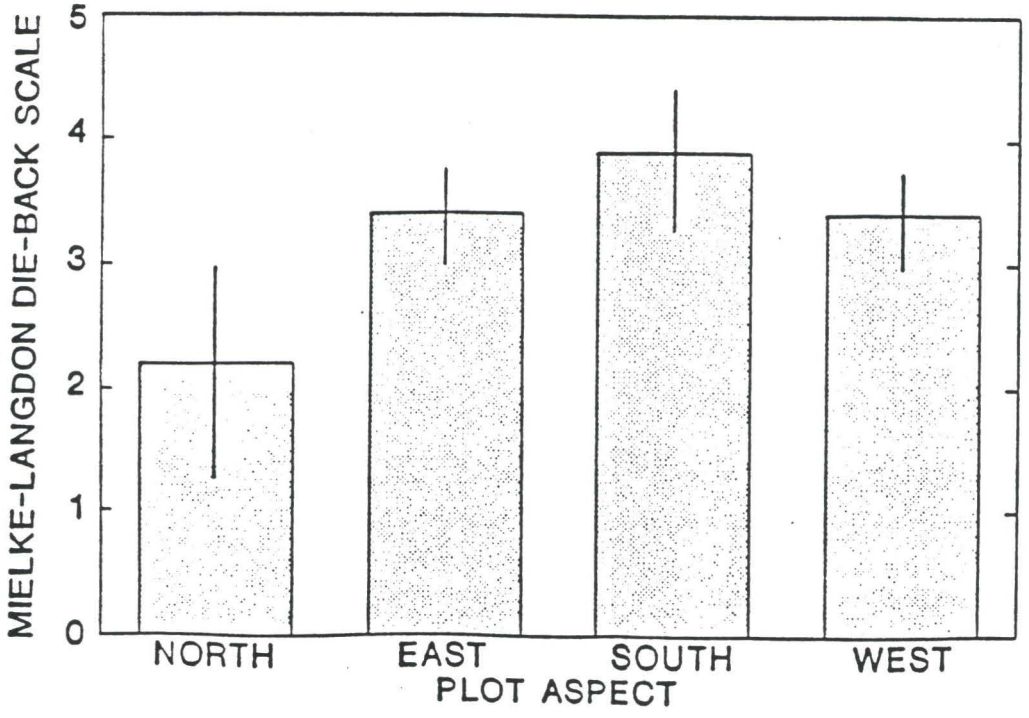


Figure 6–Relationship between plot aspect (direction plot slopes) and dogwood anthracnose symptom severity. Aspect classes are N (north) = 316-45°, E (east) = 46-135°, S (south) = 136-225°, and W (west) = 226-315°. Mielke-Langdon scale is explained in figure 5.



Effect of Tree Placement and Plot Aspect on Dogwood Anthracnose Disease Severity and Dogwood Reporduction

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Dogwoods along the Blue Ridge Parkway in Virginia, the Cherokee National Forest in Polk County, Tennessee, and Lookout Mountain in Tennessee were examined for dogwood anthracnose symptoms and reproductive potential. Tree locations were examined for factors that might affect disease severity. For each tree, disease severity, reproduction, and tree-placement data were recorded. At each location, plot aspect and elevation data were collected. Tree placement was determined as the tree being in a sunny or shady location. Disease severity was estimated by the following scales:

Mielke-Langdon Scale	
Healthy tree	= 5
Diseased foliage:	
1-25%	= 4
26-50%	= 3
51-75%	= 2
76-100%	= 1
Dead tree	= 0

Modified Barratt-Horsfall Scale	
Healthy tree	= 0
Canopy diseased:	
< 3%	= 1
< 6%	= 2
< 12%	= 3
< 25%	= 4
< 50%	= 5
< 75%	= 6
< 87%	= 7
< 93%	= 8
< 96%	= 9
100%	=10
Dead tree	=11

Percentage of the canopy that was dead was estimated using the modified Barratt-Horsfall (HB) Scale. HB ratings were converted to either percentage of diseased foliage or canopy or percentage of canopy dead using conversion tables developed by Redman and others (1). Reproduction was estimated for each tree using the following scale:

0 = no seedlings, berries, or viable flower buds

1 = a few berries or viable flower buds in one portion of the canopy

2 = berries or viable flower buds scattered in trees, and/or a few seedlings around tree

3 = heavy berry or flower bud set and/or many seedlings around tree

Results

Along the Blue Ridge Parkway, tree placement affected the amount of diseased foliage (fig. 1), disease severity (fig. 2), the amount of the canopy that had died (fig. 3), tree death (fig. 4), and tree reproduction rate (fig. 5) at most plot locations. Trees in sunny locations were less likely to be severely impacted by dogwood anthracnose as were trees in deep shade. A reduction in reproduction rates in shady locations was attributed to dogwood anthracnose, but trees located in sunny locations usually are more prolific bloomers than trees in deep shady areas (personal observation).

In Cherokee National Forest, plot aspect and elevation affected disease severity (fig. 6), the amount of canopy that was diseased (fig. 7), and dogwood reproduction rate (fig. 8). Trees located at higher elevations were more severely impacted by dogwood anthracnose than were trees at lower elevations. In plots located at less than 460 m, plot aspect had a significant affect on disease severity and percentage diseased canopy. At higher elevations, the disease was so severe that aspect effects on disease severity and percentage of diseased canopy were less apparent, but still statistically significant. Dogwood reproduction was significantly greater in plots with a south to west aspect at lower elevations (< 460 m) than in plots with a north to east aspect (> 460 m). However, at high elevations, aspect effects on reproduction were not significantly different.

At Lookout Mountain, tree placement and plot aspect affected disease severity (fig. 9) and reproduction rate (fig. 10). Plot elevations ranged from 500 to 624 m. Unlike the data collected in the Cherokee National Forest, aspect effects were significant at high elevations (above 460 m). Plots at Lookout Mountain were in urban habitats unlike the forest habitats in Polk County. Disease severity scores were less at the higher disease pressure at Lookout Mountain (when compared with plots above 460 m in Polk County), which may explain why dogwood reproduction was higher at Lookout Mountain.

Literature Cited

1. Redman, C.E., King, E.P., and Brown, I.F., Jr. 1969. Tables for conversion of Barratt-Horsfall rating scores to estimate mean percentages. Mimeo, unnumbered. Elanco Products Co., Indianapolis, IN.

Figure 1-Effect of tree placement on percentage of tree canopy displaying anthracnose symptoms (estimated using Barratt-Horsfall scale) at five locations along the Blue Ridge Parkway. At each placement site 10 trees were examined. For each column pair, * indicates that means differ according to two sample t-tests (p = 0.05).

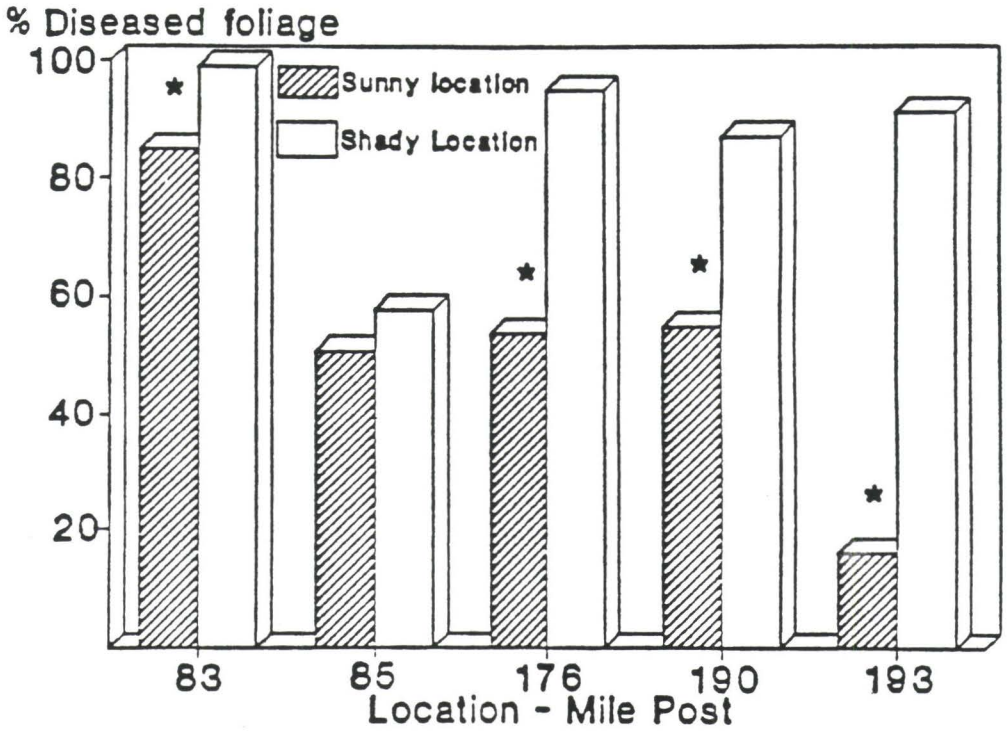


Figure 2-Effect of tree placement on anthracnose symptom severity (estimated with Mielke-Langdon scale) at five locations along Blue Ridge Parkway. At each placement site, 10 trees were examined. For each column pair, * indicates that means differ according to two sample t-tests (p = 0.05).

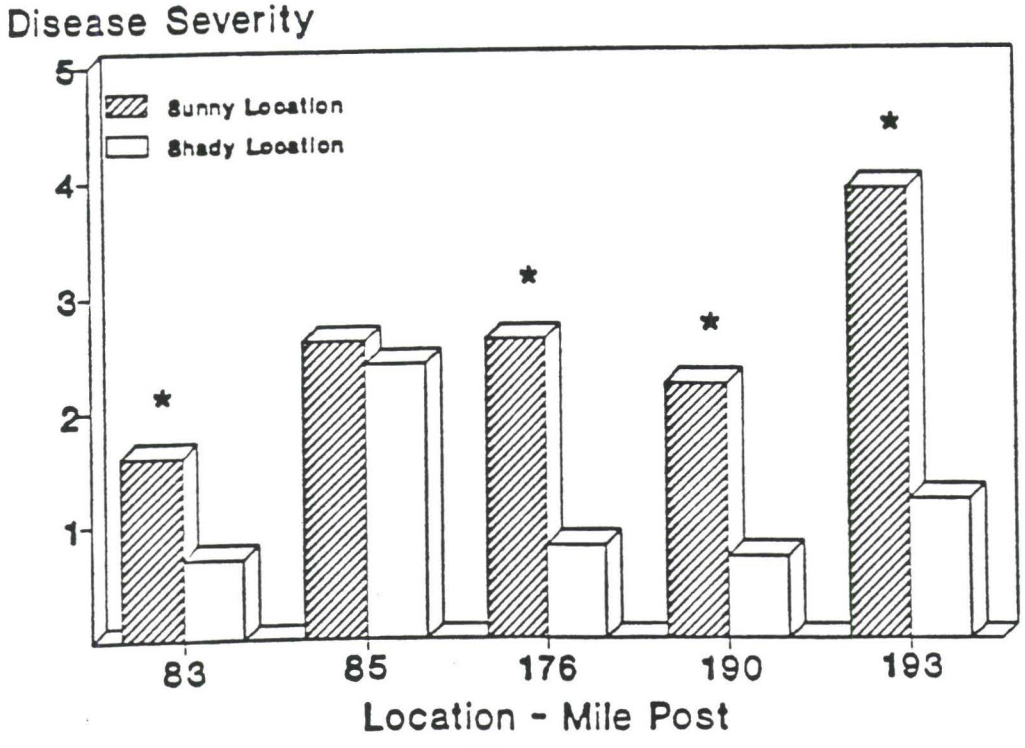


Figure 3-Effect of tree placement on tree canopy death at five locations along the Blue Ridge Parkway. At each tree placement site, 10 trees were examined. For each column, * indicates that means differ according to two sample t-tests (p = 0.05).

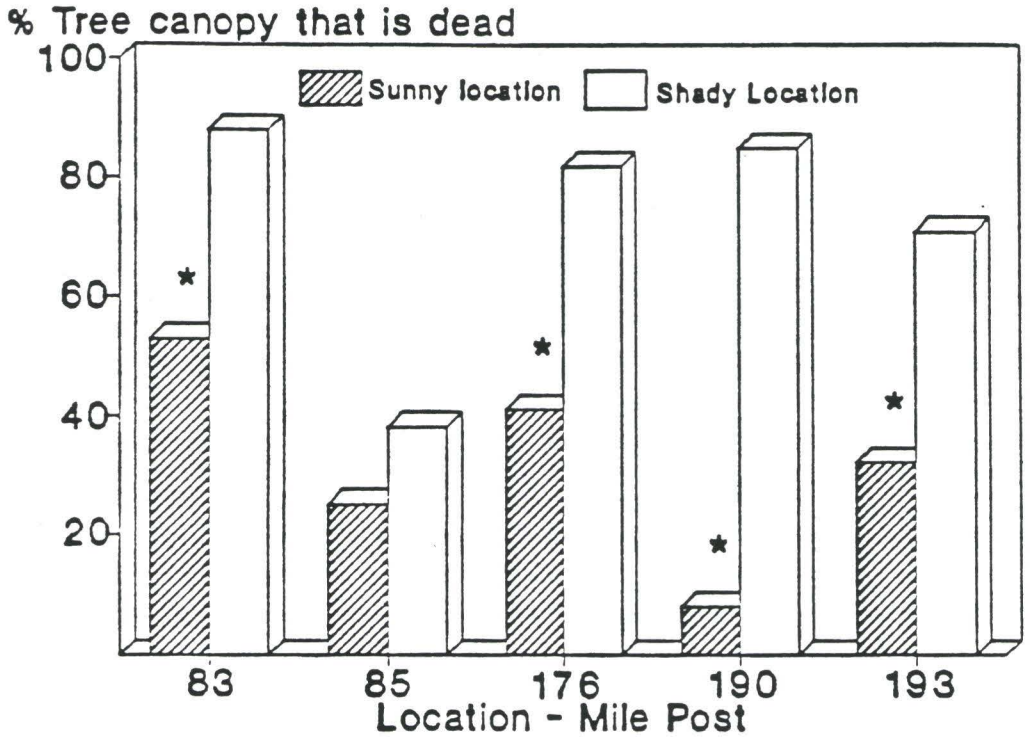


Figure 4-Effect of tree placement on tree death attributed to dogwood anthracnose. At each tree placement site, 10 trees were examined. For each column pair, * indicates that means differ according to two sample t-tests (p = 0.05).

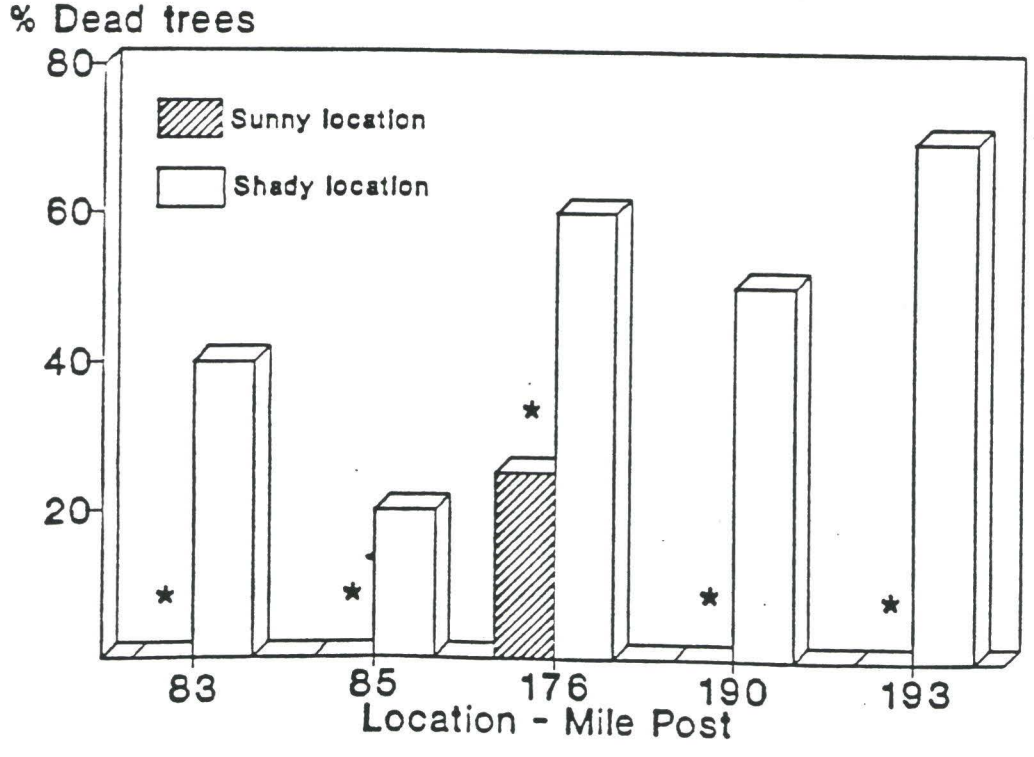


Figure 5-Effect of tree placement on reproduction rate at five locations along the Blue Ridge Parkway. At each placement site, 10 trees were examined. For each column pair, * indicates that means differ according to two sample t-tests (p = 0.05).

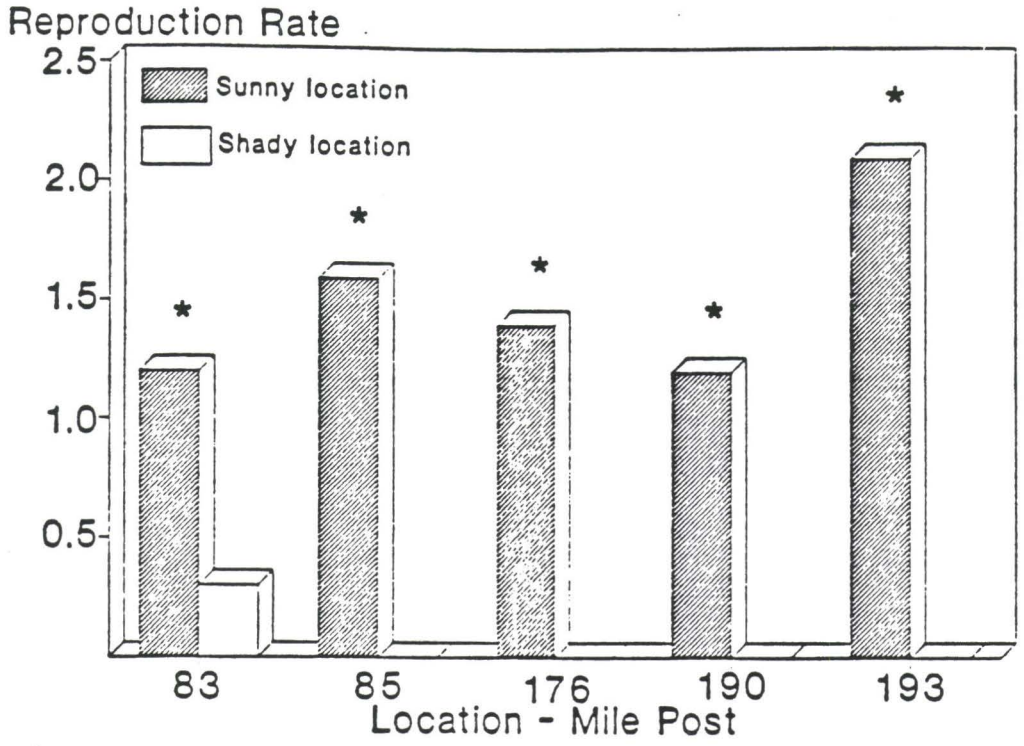


Figure 6-Effect of plot aspect and elevation on anthracnose symptom severity (estimated with Mielke-Langdon scale) in Cherokee National Forest. Means are for 10 trees in 14 plots for each elevation class. Bars represent standard error of the mean.

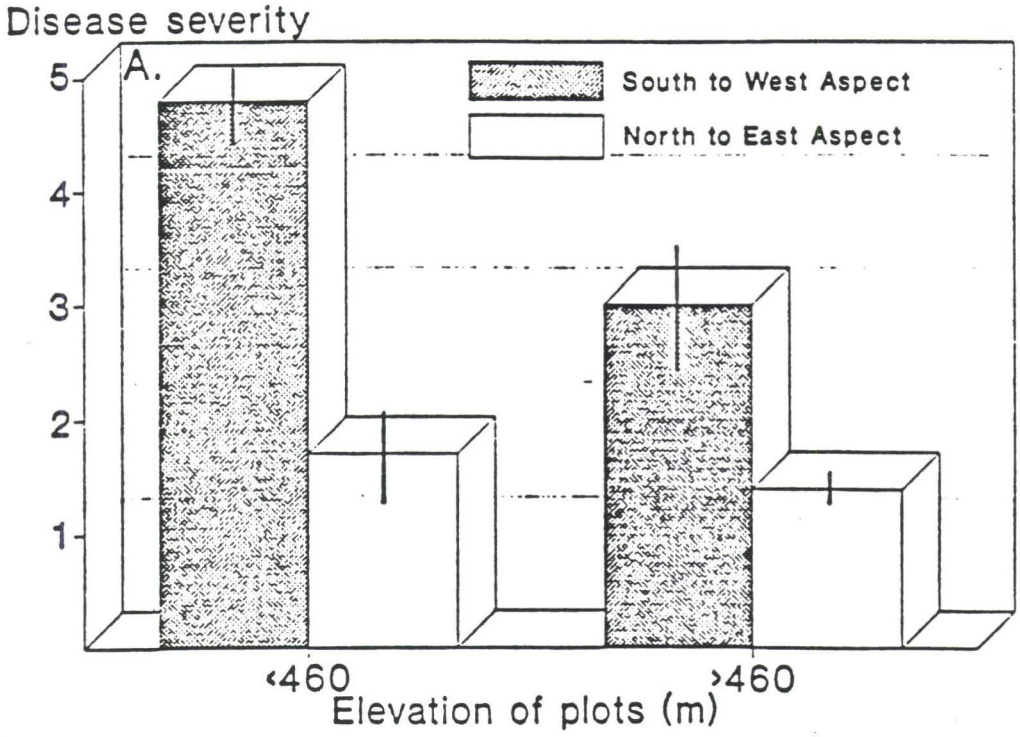


Figure 7-Effect of plot aspect and elevation on percentage of canopy displaying anthracnose symptoms (using Barratt-Horsfall scale) in Cherokee National Forest. Means are for 10 trees in each of 14 plots for each elevation class. Bars represent standard error of the mean.

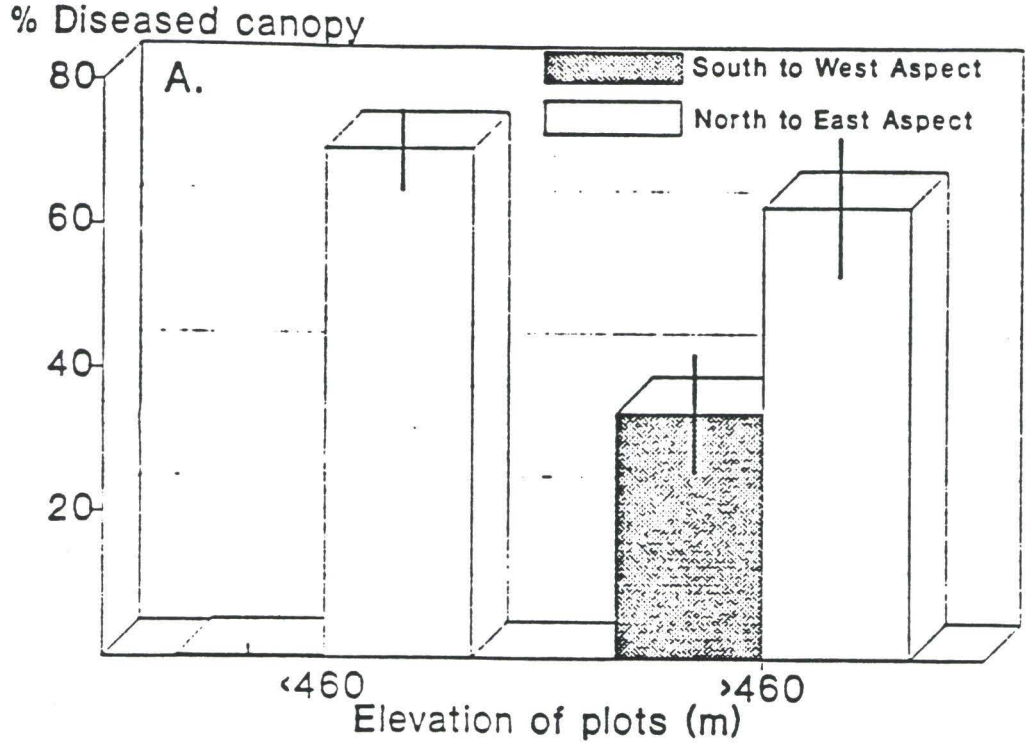


Figure 8-Effect of plot aspect and elevation on reproduction rate in Cherokee National Forest. Means are for 10 trees in each of 14 plots for each elevation class. Bars represent standard error of the mean.

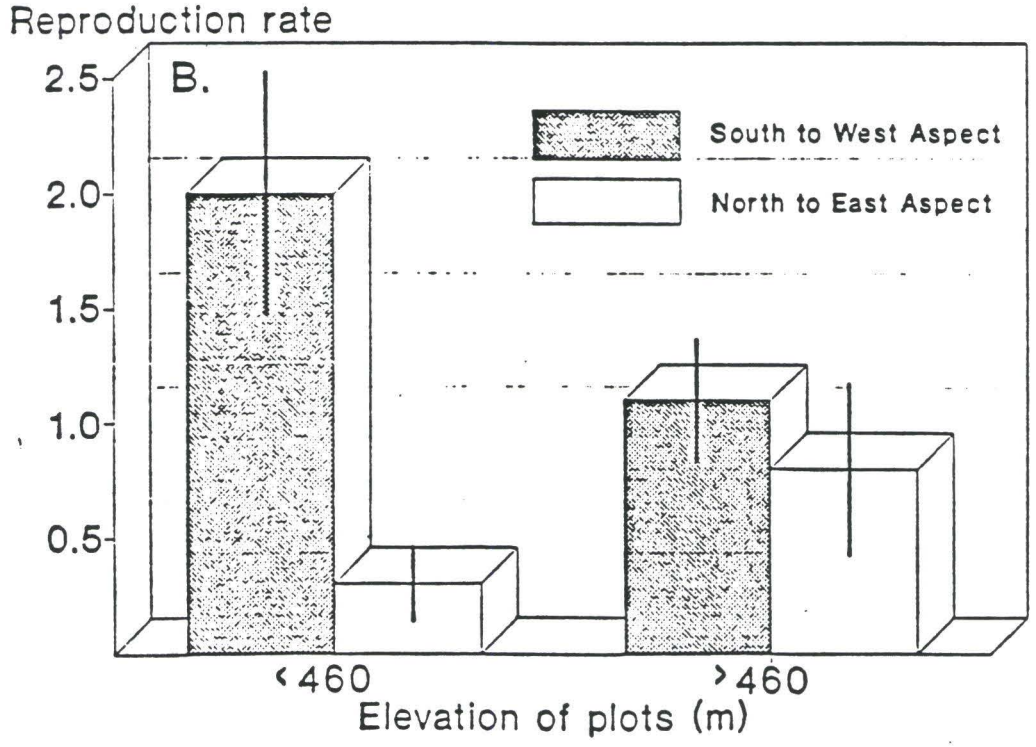


Figure 9–Effect of tree placement and aspect on anthracnose disease severity (estimated with Mielke-Langdon scale). Means are for 10 trees in each of 5 plots at Lookout Mountain in Tennessee. Bars represent standard error of the mean.

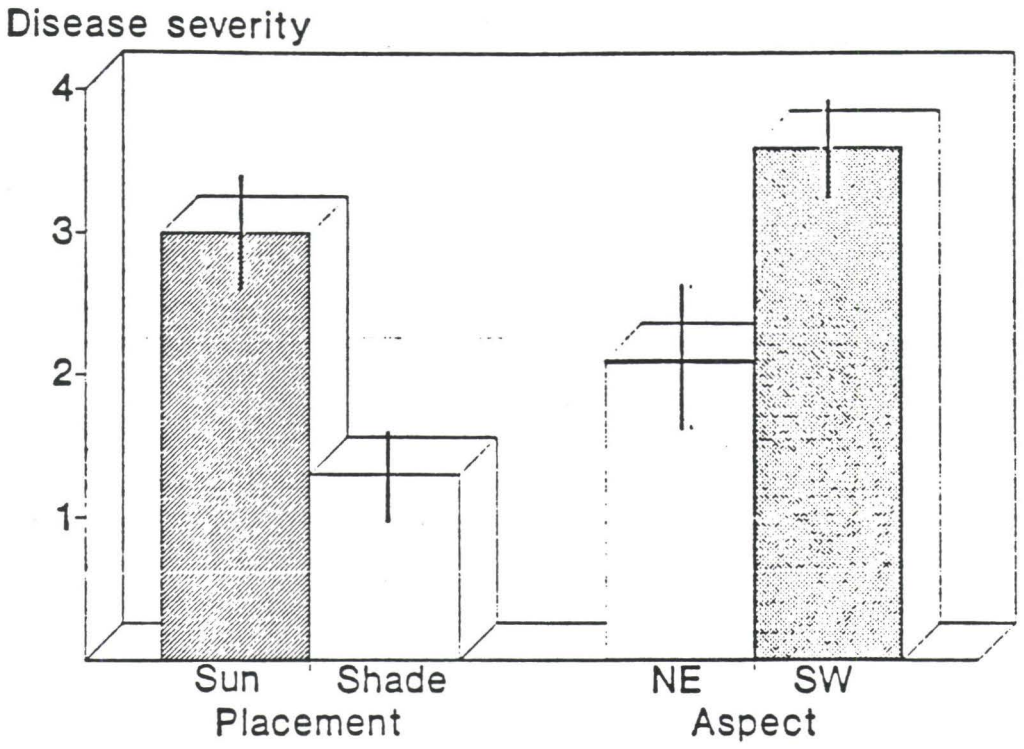
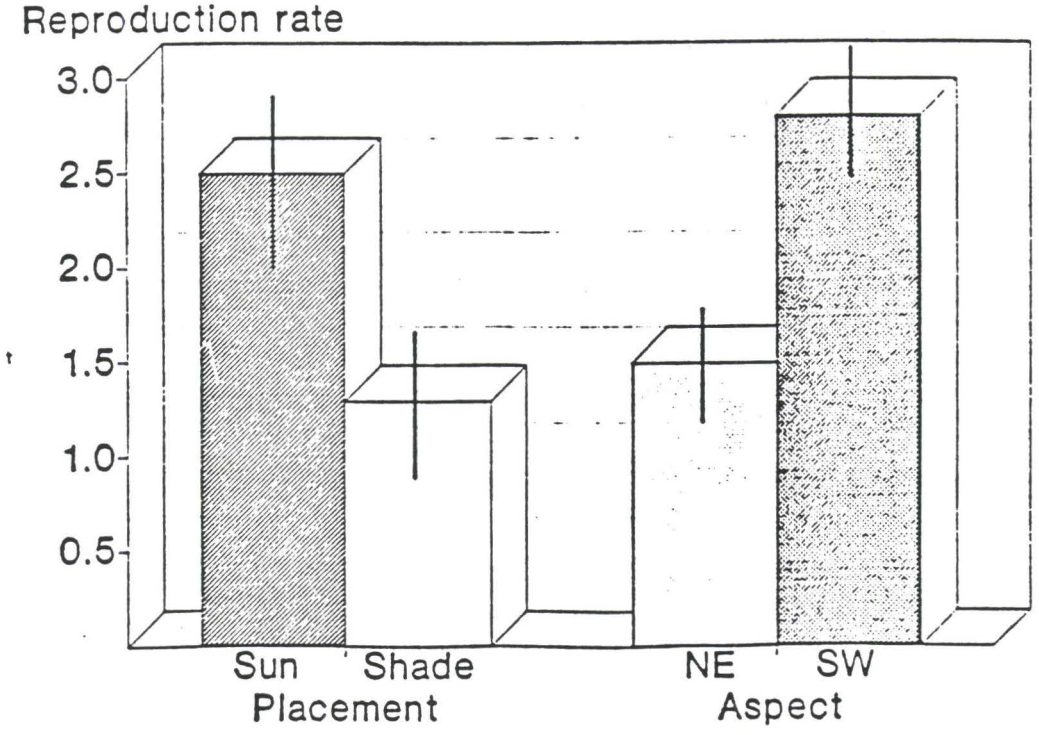


Figure 10–Effect of tree placement and aspect on dogwood reproduction. Means are for 10 trees in each of 5 plots at Lookout Mountain in Tennessee. Bars represent standard error of the mean.



Report #92-1-03

Effectiveness of Cultural Techniques, With Emphasis on Fertilization, to Control Dogwood Anthracnose

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Abstract

Ornamental dogwood trees at the Bent Creek Experimental Forest in Asheville, NC, were treated with different cultural techniques. All treated trees were pruned, mulched, and sprayed for dogwood borers. In addition, some trees received nitrogen, phosphorus, lime, or a balanced fertilizer or were watered during dry periods in 1990. Check trees received none of the treatments. These trees received only pruning, mulching, and dogwood borer control in 1991. Watering was not needed in 1991. All trees were scored for disease symptoms on a score from 100 to 0, most severe to healthy, respectively. All fertilizer treatments were correlated with reduced disease development. Nitrogen and phosphorous fertilization led to significantly lower disease ratings. It appears that any fertilization, especially with nitrogen and phosphorous, was beneficial in reducing disease severity.

Introduction

Dogwood anthracnose was found in the Northeastern United States in the late 1970's. The Northeast recommended a number of cultural control techniques for dogwood anthracnose. Since the South has a longer growing season and a variety of environmental conditions, Region 8, Forest Pest Management, began a pilot test in 1989 to evaluate these control recommendations under southern conditions.

At the Bent Creek Experimental Forest in Asheville, NC, a number of ornamental dogwoods became infected in 1989. The dogwoods were treated as recommended by the North, except no fungicides were applied. There were no prolonged dry periods in 1989, so watering was not needed. Five trees designated as checks received no treatment.

In 1990, the evaluation was continued and expanded to evaluate the effects of watering during dry periods or fertilization with high rates of nitrogen, phosphorus, lime, or a balanced fertilizer.

In 1991, the evaluation was continued with mulching, pruning, and dogwood borer treatments only.

Methods

All treated trees were pruned, mulched, and treated with Dursban for dogwood borer control in 1990 and 1991. Five trees were left untreated as checks. The following treatments were applied in the spring of 1990:

(1) Watering during prolonged dry periods, plus 10-20-10 fertilizer (rate:1.5 lb/diameter inch)
(2) Fertilizing with a high nitrogen (16-0-0) fertilizer (rate:3 lb/diameter inch)
(3) Fertilizing with a high phosphorus (0-46-0) fertilizer (rate:5 lb/diameter inch)
(4) Fertilizing with lime only (rate:200 lb/1,000 ft^2)
(5) Fertilizing with recommended fertilizer after soil analysis (10-20-10) (rate:1.5 lb/diameter inch)

Each treatment was replicated twice with three to six trees per replication. A buffer zone was left around each treatment to prevent different treatments from affecting each other. The fertilizer and lime were applied by broadcasting the material between the trunk and drip line. A soil analysis was made of each replication area before and at the end of the growing season in 1990.

The trees were rated for dogwood anthracnose in May, June, July, and August (1991) by finding the least affected and the most affected trees, which received scores of 0 and 100 percent, respectively. All other trees were fit on the scale from 0 to 100 percent by visual estimate.

Results and Discussion

Analysis of variance (table 1) revealed a significant difference among treatments at the 0.05 level of confidence. The high rates of nitrogen and phosphorus had the lowest amount of *Discula* sp. symptoms. The lime treatment, balanced and no treatment had the same severity of symptoms (table 2).

Basically, the data show that any type of fertilization coupled with the mulching, pruning, and dogwood borer control resulted in reduced dogwood anthracnose symptoms. Also, for some reason which is not fully understood, the nitrogen or phosphorous alone reduced the symptoms more than the lime or balanced. In 1991, the water treatment was the same as the balanced since we did not need to water the trees.

These data support the recommendation made in the "Growing and Maintaining Healthy Dogwoods" publication (1) that recommends fertilization according to a soil analysis.

Tests are underway with the University of Georgia and North Carolina State University to help clarify the rate and type of fertilization. It also needs to be reinforced that the other cultural practices such as pruning, mulching, and dogwood borer control are part of this integrated approach.

Literature Cited

1. **Bailey, Kenneth R. and Edward A. Brown II.** 1991. Growing and Maintaining Healthy Dogwoods, USDA Forest Service, Southern Region, Forestry Report R8-FR14.

Table 1--Analysis of variance for dogwoods treated with different types of fertilizers to assess the effects on dogwood anthracnose

Source of variation	Degrees of freedom	Sum of squares	Mean Squares	F	Probability
Among runs	11	5233.76	475.80		
Seedlots	5	4280.98	856.20	4.67 *	0.05
Runs	1	35.59	35.59	0.19	0.65
Seedlots x runs (experimental error)	5	917.19	183.44	0.32	0.89
Among replicate trays within runs (sampling error)	37	17043.04	460.62		
Total	48	22276.80			

Repeatability = 0.79

* Statistically significant at the 0.05 level.

Table 2--Duncan's multiple range test for different treatments imposed on dogwoods infected with Discula sp.

Seedlot	Test mean	Duncan's multiple range on seedlot test means
High phosphorus	5	*
High nitrogen	5	*
Water during drought	14	* *
Lime	18	* *
Balanced (NPK)[1/]	19	* *
No treatment	29	*

[1/] N = nitrogen, P = phosphorus, K = potassium.

Dogwood Anthracnose
Progress Report - 1991

Effect of Nitrogen and Phosphorus Fertilization on Infection and Disease Development

R.W. Roncadori and F.F. Hendrix
University of Georgia

The field study established in 1990 at the Georgia Mountain Experiment Station in Blairsville, GA, was continued in 1991. Nitrogen and phosphorus (alone and in combination) were applied to attain medium and high soil fertility recommended for dogwood growth. Soil tests conducted at the University of Georgia Soil and Plant Testing Laboratory indicated that nitrogen was in the low range and P in the medium fertility range. Since calcium was in the very high range, we omitted this nutrient from the study. On April 24, we applied 150 lb/A ammonium nitrate and 110 lb/A super phosphate to obtain high N and P fertility. Plots not fertilized were considered to have medium N and P fertility. On May 15, an additional 150 lbs of ammonium nitrate was applied to the high nitrogen plots. Each treatment (total of four) contained four trees per replicate and was replicated 10 times in a completely randomized design. The trees were irrigated approximately two times a week to promote anthracnose development, and all trees were artificially inoculated in mid-April and mid-June. Trees were observed once a month and final readings were taken on September 23. Very little dogwood anthracnose was observed. Instead, we detected extensive development of spot anthracnose and septoria leaf spot. We intend to continue this study in 1992 with the addition of shade cloth to promote anthracnose development.

PROGRESS REPORT
(1991)

A Cooperative Pilot Test to Determine the Effects of Media pH, Fertilization Rates, and Moisture Stress on the Infection by the Dogwood Anthracnose Fungus (*Discula* sp.) on Flowering Dogwood, *Cornus florida* L.

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C. Ray Campbell
North Carolina Agriculture Agronomic Division

Robert L. Anderson and John L. Knighten
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Abstract

Three hundred and thirty budded dogwood plants were potted in 3 pH levels (5.5, 6.0, and 6.5) and fertilized weekly with 3 levels of nitrogen (50, 100, and 200 p/m N). There was also a high phosphorous and a moisture stress treatment. There were two artificial inoculations with natural inoculum in the field locations. Only one of the six replications had significant infection. In that one replica, the higher nitrogen treatment had a higher infection level. All treated plants looked healthier than the other dogwoods in the area.

Methods

About 500 budded dogwood liners were potted in 3-gallon pots. The study used the most uniform 330 seedlings. The plants were potted and maintained at the Mountain Horticultural Crops Research and Extension Center (MHCREC) facilities in Fletcher, NC, until the leaves expanded. All treatments were established at this time. After the leaves were expanded and the 330 seedlings were chosen, the plants were moved to the USDA Forest Service facilities at Bent Creek, NC.

Three pH levels (5.5, 6.0, and 6.5) (table 1) were established in the container media by applying limestone. The plants were fertilized weekly with 3 levels of nitrogen (50, 100, and 200 p/m N) (table 1). There was a high phosphorous and a moisture stress treatment using the pH 6.0 and 100 p/m N as the control. The test design consists of five plants per treatment in each of the six locations for a total of 330 plants.

The Forest Service staff watered the plants (as needed) and assisted the MHCREC staff in fertilizing the plants once they were moved to Bent Creek.

At the same time the plants were growing at MHCREC, the dogwood anthracnose fungus (*Discula* sp.) was being cultured in the Forest Service laboratory to produce conidia for inoculum to inoculate the dogwood seedlings. Two artificial inoculations were made.

Foliar nutrient analysis were conducted on the plants on three sample dates beginning when the leaves expand in May.

MHCREC furnished its facilities, and planned and supervised plant maintenance (potting, fertilizing, watering regimes, etc.). The Forest Service furnished its facilities, and planned and supervised dogwood anthracnose fungus procedures (isolate, grow conidia, etc.), inoculations, and readings. Foliar nutrient analysis was done by the North Carolina Agriculture Agronomic Division Laboratory.

Results and Discussion

All treated trees looked healthier than the dogwoods growing wild in the area. Only one of the six replications had significant infection, even though all the overstory trees were severely infected. In that one replication, the higher nitrogen treatment was the most severely infected. In the moisture stress treatment, moisture was absorbed through the bottom of the pot.

The fertilizer treatments and project design will be modified in 1992, and the study will be repeated.

Table 1--Dogwood anthracnose treatment table

Treatment	pH	N rate (p/m)	P rate (p/m)
1	5.5	50	30
2	5.5	100	30
3	5.5	200	30
4	6.0	50	30
5	6.0	100	30
6	6.0	200	30
7	6.5	50	30
8	6.5	100	30
9	6.5	200	30
10	6.5	100	60
11	6.0	100	30

Control of Dogwood Anthracnose With Fungicide Treatments at Two locations in Tennessee

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University of Tennessee Agricultural Institute, Knoxville, TN 37901

Twelve fungicide treatments, plus an untreated control, were evaluated at two locations, Roaring Fork Creek in the Great Smoky Mountain National Park (GSMNP) and Ozone, TN. Fungicide treatments, rates, and application intervals are given in table 1. A spreader-sticker (Triton B-1956) was added to each fungicide solution/suspension at a rate of one drop/3.78 L. Experiments were started on May 2 at GSMNP and on May 8 at Ozone. Fungicide applications were continued till the end of August.

Each fungicide treatment was sprayed to run off on seven potted dogwood trees at each location. Dogwood trees were approximately 1 m high. At each location, seven naturally propagated trees with severe anthracnose symptoms were selected to serve as inoculum sources. The potted trees were arranged in a randomized block design with seven reps. One tree of each fungicide treatment and one control tree was placed underneath each one of the source trees.

Disease severity was estimated for each fungicide treatment and the control using the Mielke-Langdon scale. Data were analyzed using the Proc GLM procedure of SAS. Duncan's multiple range test was used to separate treatment means.

Results

Fungicide treatments were effective in reducing disease severity at both locations (table 2). Phytotoxicity symptoms were observed only after applying Banner at concentrations of 0.31 mL/L (mild leaf distortion, leaf distortion, and silvery appearance of leaves) and 0.63 mL/L (necrotic flecking, leaf distortion, and silvery appearance of leaves). These symptoms were more severe on trees at GSMNP than on trees at Ozone. Phytotoxicity symptoms in trees sprayed with 0.31 mL/L Banner were barely distinguishable at both locations.

High rates of Banner and Lynx gave control when applied at 4-week intervals. If the time between applications could be lengthened, treatments by homeowners might become more practical and less costly. More research in this area is needed.

Table 1--List of fungicides, rates used, and application intervals used at two sites (Roaring Fork Creek in the Great Smoky Mountain National Park and at Ozone,

Fungicide treatment	Concentration (per liter)	Interval (weeks)
ASC 66719	2.3 g	2
Banner 1.1 E	0.16 mL	2
Banner 1.1 E	0.31 mL	2
Banner 1.1 E	0.63 mL	2
Banner 1.1 E	0.63 mL	4
Benlate 50 DF	1.2 g	2
Bravo 720	2.4 mL	2
Dithane DF	1.8 g	2
Lynx	2.0 mL	2
Lynx	6.0 mL	4
SAN 619	0.3 g	2
Systhane 2 EC	0.32 mL	2

Table 2--Effectiveness of fungicidal treatments at Roaring Fork Creek in the Great Smoky Mountain National Park and at Ozone, TN

Fungicide treatment	Disease severity*			
	GSMNP		Ozone	
	6/25	8/21	6/27	8/23
ASC 66179	4.8a	4.0a	4.6ab	3.8a
Banner 0.16 mL	5.0a	4.2a	4.7ab	4.0a
Banner 0.31 mL	4.9a	4.0a	4.4a	4.0a
Banner 0.63 mL/2 wk	4.9a	4.4a	4.3ab	4.3a
Banner 0.63 mL/4 wk	4.2a	3.8a	4.0ab	3.7ab
Benlate	4.8a	4.0a	4.4ab	4.4a
Bravo	4.4a	3.9a	4.3ab	4.1a
Dithane	4.8a	3.6ab	4.4ab	3.9a
Lynx 2 mL	4.9a	4.3a	4.3ab	4.2a
Lynx 6 mL	5.0a	3.8a	4.5ab	3.7ab
SAN 619	4.9a	4.0a	4.4ab	4.0a
Systhane	4.7a	3.7ab	4.5ab	3.5ab
Control	4.0a	2.4 c	3.8 b	2.6 c

*Disease severity was estimated using Mielke-Langdon scale where 5 = healthy, 4 = 1-25%, 3 = 26-50%, 2 = 51-75%, 1 = 76-100% diseased foliage, and 0 = dead tree.

abc for each column, means followed by the same letter do not differ according to Duncan's multiple range test (0 = 0.05).

Dogwood Anthracnose Progress Report - 1991

Evaluation of Fungicide Foliar Sprays and Trunk Injections on Control of Dogwood Anthracnose

R.W. Roncadori and F.F. Hendrix
University of Georgia

This study was established in the Duke's Creek Falls area of the Georgia Mountains where the disease has been epidemic. Foliar sprays were applied to both leaf surfaces until runoff using a backpack sprayer. Applications were begun on April 2 and continued on a 2-week schedule, unless otherwise indicated, until June 12 (6 sprays). Treatment 5 consisted of Lynx on a 2-week schedule with the fifth spray omitted to provide a 1-month interval. Treatments are listed in the attached table and each was replicated four times in a completely randomized design.

Trunk injections were completed on May 1 and included the fungicides listed in the following table. Injections with the Mauget instrument (4 mL/injector) were placed 12 cm apart near the root flare. Two Aliette injections (20 mL formulation/site) were made per tree opposite each other. Trees in this study ranged from approximately 7.5 to 15.0 cm d.b.h. Each treatment was replicated four times in a completely randomized design.

Disease assessments were based on estimated percentages of individual leaves with necrosis, on a scale of: 0 = no symptoms, 1 = trace to 5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100%, and 6 = leaf abscised. Twenty-five leaf pairs in the lower crown of each tree were rated on May 29 and July 3, 1991. Data were analyzed by analysis of variance and means separated by the Duncan's multiple range test, $P = 0.05$.

Significant disease control occurred with both foliar sprays and trunk injections (see table). Although all foliar sprays effectively reduced leaf infection, best results were obtained with Lynx, Asc 66825, and Benlate. Trunk injection was relatively ineffective compared with foliar sprays. Control was provided by Lynx, Aliette, and Arbotect injections.

Dogwood Anthracnose Fungicide Tests
1991

	Treatment/Rate*	Disease rating 5-29-91	Disease rating 7-3-91
	Spray treatments		
1.	Control	2.585 A**	2.665 A
2.	Daconil 5.7 g/gal	1.485 B	1.320 B
3.	Benlate 4.6 g/gal	1.130 C	0.750 E
4.	Lynx 3.0 mL/gal	0.890 D	0.815 D
5.	Lynx 3.0 mL/gal	0.615 F	0.470 G
6.	Asc 66825 4.5 g/gal	0.270 G	0.500 F
7.	Asc 66825 9.0 g/gal	0.880 E	0.835 C
	Mauget Tree Injectors		
9.	Arbotect	2.3300 C	2.1850 C
10.	Lynx	2.440 C	1.9550 D
11.	Plant Vax	2.2700 C	2.6000 B
12.	Plant Vax & Arbotect	3.0150 B	3.1800 A
13.	Control	3.3050 A	2.7750 B
	Syringe Injectors		
8.	Aliette	1.5632 B	1.3550 B
14.	Control	2.5800 A	1.6400 A

* = Formulated rate

Aliette	- 9.5% a.i.
Arbotect	- 2.0% a.i.
ASC 66825	- 50 WP
Benlate	- 50% DF
Daconil 2787	- 90 DG
Lynx	- 2 F
Plant Vax	- 2.0% a.i.

** = p = 0.05 Duncan's multiple range test

Report #91-1-43

Development of an Inoculation System for Infection of Flowering Dogwoods With *Discula* sp. at the Resistance Screening Center, 1991

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Abstract

Several systems for screening dogwood seedlings for resistance to *Discula* sp. were evaluated at the Resistance Screening Center. The system yielding the best results was an open-field area covered by shade cloth and misted to maintain high humidity. The inoculation procedures consisted of suspending infected branches over the seedling and spraying spore suspensions onto seedlings.

Introduction

Dogwood anthracnose, caused by *Discula* sp., was discovered in the United States in the late 1970's. It has since killed millions of trees. After 4 years of monitoring in the Southeastern United States, presence of the disease has been confirmed in 120 counties in 7 Southern States. It is estimated that over 6 million acres are affected. In some areas, dogwood mortality is 100 percent.

Occasionally, a tree is observed that may be resistant to the fungus. However, no operational procedures exist to assess the potential resistance. The Southern Region of the USDA Forest Service is interested in screening dogwood selections across the region for potential resistance. Identification of such resistance could be the first step in establishment of a seed orchard of resistant dogwood. The Resistance Screening Center in Asheville, NC, and the Southeastern Forest Experiment Station were asked by the Southern Region to develop an operational screening procedure.

This report presents the results of the 1991 field season at the Resistance Screening Center.

Methods

Germinating dogwood seedlings (about 2 inches tall) were transplanted into 1-L containers filled with metro-mix. These seedlings were maintained in a greenhouse. An additional group of seedlings was germinated in sand and transplanted into a flat of metro-mix.

There were several inoculation procedures:

1. Woods Inoculation - One-inch PVC pipe was used to make a rack 4 feet tall, 4 feet wide, and 8 feet long. A plastic screen was installed on the top to hold infected leaves and branches, and the system was placed in full shade in the woods. Six-inch-tall seedlings in the 1-L pots were placed about 6 inches apart on the ground in the system. Infected leaves and branches were suspended about 3 feet over the seedlings. One-half of the seedlings were inoculated with a spray of 2,000 spores per mL applied 1 day after placement in the woods.

2. Open-Field Inoculation (6-inch-tall seedlings) - One-inch PVC pipe was used to construct a frame 5 feet wide, 6 feet tall, and 61 feet long. A plastic rack was installed 3 1/2 feet from seedling tops to suspend infected leaves and branches. Misting nozzles were installed above the infected leaves to inject a penetrating fog and mist through the infected branches. In addition, a backup watering system was added below the infected leaves. The whole system was then covered with shade cloth to provide 73 percent shade. Six-inch-tall seedlings in 1-L pots were placed on the ground about 6 inches apart. One-third of the seedlings had only infected branches suspended over them. One-third had the infected branches plus artificial inoculation at 2,000 spores per mL. The remaining third received artificial inoculations only.

3. Open-Field Inoculation (2-inch-tall seedlings) - Two-inch-tall seedlings were grown in metro-mix about 2 inches apart in a tray measuring 2 feet by 2 feet. This tray was placed in the system described in number 2. The seedlings were artificially inoculated at the rate of 2,000 spores per ml 1 day after placement in the system.

Seedlings in the woods inoculation study received no moisture treatments, whereas all seedlings in the open-field study did. Moisture was applied by misting daily from 10 a.m. to 5 p.m. (unless it was raining).

All seedlings were checked weekly for symptom development. The seedlings were inoculated on June 21 and read on July 20. Each tree was examined for (1) infection, (2) percent of the leaves showing symptoms, (3) percent of the leaf area affected for the symptomatic leaves, and (4) percent of leaf area affected for the most severely affected leaf on the seedling. Twenty leaves were picked from each treatment and checked to ensure that *Discula* sp. was present in the symptomatic tissues. General observations were made on seedling condition.

Results and Discussion

After 30 days, symptoms had developed enough to be read. Percentages of seedlings affected, leaves affected, leaf area affected for symptomatic leaves, and leaf area affected on the most severely affected leaf on a seedling are shown in table 1. All of the techniques provided useful information. The woods-treated seedlings had very light infection, which would make it difficult to estimate seedling susceptibility. The open-field 3-inch seedlings provided good information, but often had only 4 to 6 small leaves–too few for adequate seedling separation. The open-field artificial inoculations gave the lowest infection in the field, while open-field natural and open-field artificial plus natural inoculation gave only slightly better results. Most of the seedlings became infected. About 50 percent of the leaves on the seedlings were symptomatic, and about 20 percent of the leaf area was affected on the symptomatic leaves. The percentage of area symptomatic on the most severely affected leaf per seedling was rejected because of a large variability.

Based on this 1 year's data, we are recommending the use of open field with shade cloth and using natural plus artificial inoculation. Clearly, the system can be improved. We plan on trying double shading and pre-inoculation in a chamber next year.

The Southern Region has been contacted and hopes to begin inoculating seed selections next year. Any selections showing resistance could be propagated and subjected to additional testing.

Table 1--Percentages of dogwood seedlings and leaves per seedling expressing dogwood anthracnose symptoms after inoculation

Procedure	Seedling height	Seedlings affected	Leaves affected/plant[1/]	Leaf area affected on symptomatic leaves[1/]	Area of most severely affected leaf per plant
	Inches	- - - - - - - - - - - - - - - - - -		Percent	- - - - - - - - - - - - - - - - - -
Woods:					
Natural inoculation	6	69	14.8/12.8	1.6/1.6	Not taken
Artificial and natural inoculation	6	88	15.9/11.3	4.4/4.3	Not taken
Open Field: (Shade cloth)					
Artificial Inoculation	3	100	56.8/12.9	27.8/11.1	51.4/18.3
Artificial Inoculation	7	92	29.8/16.9	4.7/4.4	15.4/22.4
Artificial and natural inoculation	7	100	64.4/15.2	20.0/7.9	49.4/25.8
Natural inoculation	7	92	47.5/16.0	17.2/8.9	47.3/28.2

[1/] First number is the average and second is the standard deviation.